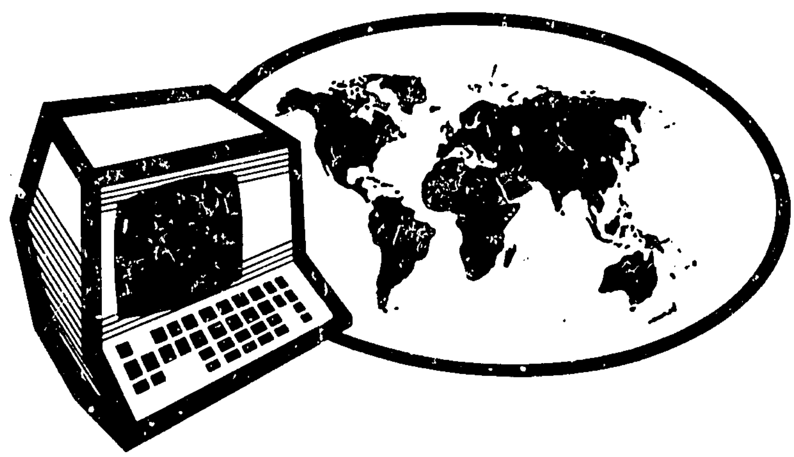
# Considerations for Use of Microcomputers in Developing Country Statistical Offices



Final Report Prepared by
International Statistical Programs Center
Bureau of the Census
U.S. Department of Commerce

Funded by
Office of the Science Advisor
Agency for International Development

Issued October 1983

**U.S. Department of Commerce**
**Malcolm Baldrige,** Secretary
**Clarence J. Brown,** Deputy Secretary

**BUREAU OF THE CENSUS**
**C.L. Kincannon,**
Deputy Director

## ACKNOWLEDGEMENTS

This study was conducted by the International Statistical Programs Center (ISPC) of the U.S. Bureau of the Census under Participating Agency Services Agreement (PASA) #STB 5543-P-CA-1100-00, "Strengthening Scientific and Technological Capacity: Low Cost Microcomputer Technology," with the U.S. Agency for International Development (AID). Funding for this project was provided as a research grant from the Office of the Science Advisor of AID. The views and opinions expressed in this report, however, are those of the authors, and do not necessarily reflect those of the sponsor.

Project implementation was performed under general management of Robert O. Bartram, Assistant Director for International Programs, and Karl K. Kindel, Chief ISPC. Winston Toby Riley III provided input as an independent consultant. Study activities and report preparation were accomplished by:

Robert R. Bair -- Principal Investigator

Barbara N. Diskin -- Project Leader/Principal Author

Lawrence I. Iskow -- Author

William K. Stuart -- Author

Rodney E. Butler -- Clerical Assistant

Jerry W. Richards -- Clerical Assistant

ISPC would like to acknowledge the many microcomputer vendors, software developers, users, the United Nations Statistical Office, and AID staff and contractors that contributed to the knowledge and experiences of the study team. This document should prove useful to statistical centers in developing countries which are attempting to establish microcomputing capabilities.

## SPECIAL INTEREST DIRECTORY

# TABLE OF CONTENTS

ix

x

# EXECUTIVE SUMMARY

## 1. Introduction

Statistical data processing in developing countries often suffers from limited access to scarce mainframe computer resources. Equipment malfunctions and shortages of replacement parts have frequently caused many users to experience long delays. Moreover, leasing equipment or paying for computer time, as many developing countries do, are costly practices.

The International Statistical Programs Center (ISPC) of the U.S. Bureau of the Census conducted a research project, funded by the U.S. Agency for International Development (AID), to study the feasibility of using microcomputers to augment mainframe computer resources in order to increase productivity and efficiency and lower the cost of data processing in national statistical offices (NSO's) of developing countries.

The study had three major components: information gathering, actual experience doing typical processing tasks on representative microcomputer systems, and documenting project activities and findings in this report. The report summarizes the activities carried out and the conclusions reached under this project started in October 1981 and completed in April 1983.

The report is intended for a wide audience interested in microcomputer technology. It provides an introduction to the technology; looks at hardware, software, and possible applications; gives guidelines for the introduction and use of microcomputers; presents case studies of current microcomputer use; and documents ISPC microcomputer experience. A glossary is included to clarify technical terms used in the report. A bibliography and chronological documentation of the project serve as further resource materials.

## 2. Findings and Recommendations

The information obtained from microcomputer users, many of whom were working in developing countries, and the experience of procuring and using microcomputers formed a good basis for judging the feasibility of applying this technology in NSO's of developing countries. The following sections attempt to summarize the findings of the study and provide an overview of the wide scope of research completed.

### 2.1 Assessment of the Technology

Microcomputer technology is sufficiently developed to make microcomputers a viable processing alternative for NSO's in developing countries. A number of microcomputers appear to be good candidates for the processing needs of NSO's. Eight-bit microcomputers are still the most popular hardware and have the most mature software. However, 16-bit and 32-bit machines are

becoming increasingly popular. They give added addressability and speed which facilitate many statistical applications. Winchester disks are available to provide reliable secondary storage.

Development of software for microcomputers has not kept pace with hardware development. The majority of available software is oriented to 8-bit systems, although there is a considerable effort to produce software for the newer 16-bit and 32-bit microcomputers. Microcomputer software, in general, can be characterized by a great degree of user-friendliness; that is, an attempt to assist the user through menus, screens which elicit specific information from the user, and information to assist the user. For the most part, software is produced primarily for popular operating systems, such as CP/M, or for hardware with a proprietary operating system, such as Apple. The more popular software packages are available under multiple operating systems. Software packages which are written for widely distributed systems tend to be of higher quality because of the demands from a larger user community and the existence of a broader capital base for maintaining software.

While the number of software packages is staggering, few address the specific needs of statistical offices. The packages that are appropriate for statistical offices focus more on support activities and analysis, rather than on editing and tabulation which form the basis of much of a statistical office's data processing requirements. There is no software capable of doing editing and tabulation such as that done by ISPC's CONCOR and CENTS 4 packages on mainframe computers.

There are many activities within an NSO which could be done effectively on microcomputers. Among these are data entry with the possibility of concurrent interactive editing; computerization of administrative data bases; statistical analysis, particularly of summary level data; word processing; and planning which makrs use of spreadsheet capability and graphics. These activities encompass a wide range of applications, including surveys of moderate size and even censuses of small areas. For the most part, NSO's will use microcomputers as general-purpose machines to perform several functions.

Microcomputer technology is not sufficiently advanced to recommend processing large-scale censuses or surveys exclusively on microcomputers. This is not to say that they are incapable of such processing, but rather that they cannot be considered equivalent to most mainframe computers for this purpose. Peripheral devices generally associated with microcomputers do not include the tape drives, high-speed printers, and large mass storage devices typically needed for large-scale processing. The absence of software for editing and tabulation such as that needed for a population census is a further problem. These deficiencies are rapidly diminishing, and it is conceivable that within 5 to 10 years microcomputer hardware and software will be capable of meeting these large-scale processing needs.

## 2.2 Current Use of Microcomputers in Developing Countries

A survey of microcomputer users revealed a considerable amount of microcomputer activity in developing countries. Apple microcomputers, followed by Radio Shack TRS-80 microcomputers, were predominant. Other vendors with moderate representation included Hewlett-Packard, Altos, Northstar, and Commodore. The recent announcement by IBM to market their Personal Computer internationally will undoubtedly shift the vendor representation in developing countries.

Microcomputers are being used successfully to process surveys and censuses in small areas, such as island nations. More ambitious census processing on microcomputers is being attempted, but has not been completed.

The use of microcomputers in developing countries is not without problems. Considerable frustration and idle microcomputer systems have resulted from hardware and software problems and inadequate training and support. The two biggest problems for developing countries attempting to use microcomputers are power supply and maintenance.

## 2.3 System Selection and Procurement

The decision to buy a microcomputer and the choice of hardware and software should be guided by one or more persons knowledgeable of the technology. If such a person cannot be located within an NSO, a consultant should be hired to aid in the decision-making process.

The correct approach to system choice includes identifying the tasks to be accomplished, software needs, and hardware requirements, and then finding a system that meets as many of the needs and requirements as possible. Other factors to be considered include such things as local vendor representation, experience with microcomputers already installed in the country, cost, and delivery time. Technical details such as appropriate voltage and number of cycles, as well as the requirement for power protection, need to be addressed.

Some degree of customization, or user-specific configuration, of a microcomputer system will often be necessary. The survey of microcomputer users showed that the vendor's basic system frequently fails to meet all the user's needs. The user may require a printer with special characteristics, an additional board to increase the number of characters displayed on the monitor screen, a numeric keypad, or something considerably more complex such as a tape drive. The new user may opt to purchase the basic system and through its use decide what should be added or upgraded. In any case, a user should consider system customization only under the following conditions: the user can identify at least one case where someone has actually done what the user plans to do, and the user has a local source of assistance if problems arise.

The NSO should formulate an overall plan for procurement of microcomputer systems, as opposed to allowing ad hoc acquisition which has the potential for incompatibility. This will not necessarily dictate a particular brand of hardware, but perhaps compatible operating systems or simply communications capability among equipment obtained. If mainframe-microcomputer communication is desired, it may be necessary to upgrade the mainframe computer in order to support communication.

Procurement and customs regulations should be studied in order to expedite the process of obtaining microcomputer systems. These can vary greatly from one country to another.

Developing countries should buy only fully integrated hardware and software. The hardware should be "burned in" for a minimum of 72 hours. The burn-in period will often catch faulty hardware before it is sent out for installation. Many problems can be avoided by obtaining the hardware and software from the same source. The responsibility for problem resolution is less ambiguous when only a single vendor is involved.

## 2.4 Support

Training in the proper use of hardware and software and in trouble-shooting is extremely important. It should incluJe the chance for each user to do exercises on a microcomputer which reinforce the material covered.

Ongoing user support is necessary to answer the many questions that arise as users become familiar with microcomputer systems and as problems arise. It must be provided by someone who is knowledgeable of both the hardware and the software involved.

Consideration must be given to maintenance. Unfortunately, it does not become important until a breakdown occurs. Redundancy of hardware provides considerable protection, no matter which maintenance route is taken. Local maintenance is, of course, preferred to having to send components away for repair. If maintenance cannot be obtained from a local firm, NSO employees can be trained to perform a degree of maintenance by swapping boards and chips.

A central or regional support group, sponsored by an international agency such as AID, could be extremely effective in providing support on many levels. These include giving central, regional, or local training; providing current information on microcomputer technology to developing countries; participating in needs assessments and system selection and procurement for individual countries; and providing trouble-shooting advice. Such a group would have to include highly-trained technicians with a knowledge of diverse microcomputer hardware systems and software packages. Furthermore, these persons would need a first-hand knowledge of providing technical assistance to developing countries.

## 2.5 Use of the Microcomputer System(s)

A microcomputer can probably best be used in combination with other computing equipment, in order to allow the access to additional resources. These might include things like faster line printers or the greater storage capacity commonly found on mainframe computers and minicomputers. This observation is based on reponse from the user survey which showed that for many applications it is desirable to be able to transfer data from one microcomputer to another or to a mainframe computer for further processing. This allows the microcomputer to be dedicated to a specific task, such as data entry or analysis, instead of forcing it to be a general-purpose machine.

The use of microcomputers in combination with other computing equipment implies the need for a communications capability which can be achieved in a number of ways. The use of a local area network to connect microcomputers is quite versatile and minimizes system degradation. It has the further advantage of not having to depend on the telephone lines, which are often unreliable. Communication with other computers can be achieved through telecommunication, hardwiring, or use of a magnetic medium for file transfer. Some computers, such as older mainframe computers, require modification to support communications.

Any task proposed for a microcomputer should be carefully thought out. A system run on a mainframe might need to be redesigned to take into consideration the strengths and weaknesses of the microcomputer. For example, time-consuming processes, such as sorting data files, could possibly be avoided by using different data structures and access methods.

The size and cost of microcomputers, as well as their claims to user-friendliness, attract users who formerly had programmers do their work on mainframe computers. These people generally utilize packaged software to manipulate data files, create budgets, query data bases, or perform statistical analysis.

Custom program development is often necessary to augment the capabilities provided by packaged software. The compilers and interpreters are still somewhat unreliable and poorly documented, for the most part. Furthermore, it is often much more difficult to work with a data file using various language processors or software packages on a microcomputer as opposed to doing the same thing on a mainframe computer. Where adequate packaged software exists, it is undoubtedly more cost-effective to use it instead of attempting to write equivalent software.

## 2.6 Impact on the National Statistical Office

Although the cost of microcomputers is low, the NSO may not realize a cost savings by their introduction because there may be widespread demand for microcomputer systems within the NSO, extending into areas that previously made no use of computing.

Furthermore, there will probably be the need to maintain mainframe capability for at least a transition period, if not indefinitely.

Microcomputers have the potential to provide more timely statistics of higher quality. It is difficult to quantify this potential improvement. Factors such as the ability to edit data at their source (as opposed to automatically imputing values without regard to recorded responses), the possibility of decentralizing data preparation to avoid a backlog in a central office, and the idea of giving policymakers access to data through their own desktop computers and graphics capability contribute to this added potential.

Persons at various levels of the NSO who formerly had limited or no connection to mainframe computer activity will be significantly affected by the introduction of microcomputers. Microcomputers may, in fact, change the description of some positions and create the need for others.

Microcomputers have the potential to ameliorate two problems which pervade NSO's. The rapid turnover of scarce data processing staff may not have as serious an effect on the overall progress of computing as more permanent personnel can assume at least some processing responsibility. The introduction of microcomputers will likely reduce the demand on generally overburdened mainframe computers for small-scale manipulation of data.

## 2.7 Considerations for Developing Countries

Local vendor representation can be extremely important to maintenance and other support. It may be advisable to compromise on some system requirements in order to obtain hardware which can be supported locally.

Redundancy of equipment provides the capability to continue processing if one system fails. If timing is at all critical, complete system redundancy is recommended.

Power supply problems can have extremely serious consequences for program and data files, as well as for system components. An Uninterruptable Power Supply (UPS) should be purchased for any system operating in a questionable power supply environment.

If local resources are not available for training and ongoing support, a means for supplying this must be identified. This may entail retaining a consultant in the country of origin of the microcomputer system (in the worst case), hiring a local expert, or sending staff to courses. Without proper training and ongoing support, the introduction of microcomputers will be severely limited or may fail altogether.

## 2.8 The Future

Microcomputer technology is changing so rapidly with so many possible alternative directions that it is difficult to predict

what course languages, operating systems, microprocessors, and software packages will take. It can be said with certainty that microcomputers will continue to become more powerful and more affordable. The technology is destined to touch everyone's life.

The situation for developing countries will only improve. Existing shortcomings in vendor representation, statistical software capability, peripheral speed, and storage will eventually disappear. The introduction of microcomputers in NSO's of developing countries is inevitable; a rational and educated use of these new tools can have a far-reaching, positive impact.

## 3. Project Implementation

### 3.1 Information Gathering

It was important to gain a thorough understanding of microcomputer technology and its current application. Information was collected by a series of questionnaires and vendor inquiries and by extensive reading of current periodicals.

#### 3.1.1 Questionnaires and Other Inquiries

Questionnaires were sent to known microcomputer users, to all NSO's, and to vendors of hardware and software. Followup inquiries were sent to vendors who chose not to return the questionnaires. In total, 125 user questionnaires were completed; information from 275 hardware vendors and 325 software vendors was received. The user questionnaires, in particular, provided excellent case study material and a good overview of actual experience in developing countries.

#### 3.1.2 Literature Search

An extensive library of books, periodicals, and papers was developed over the course of the study. It was necessary to devote a considerable amount of time to reading this literature in order to attempt to stay abreast of developments in the rapidly changing microcomputer industry. A microcomputer-based file having tree-like keyword identifiers was developed to record pertinent information on all aspects of the technology for easy future retrieval.

### 3.2 Microcomputer Systems Procured

Two microcomputers, representative of the high and low ends of microcomputer technology, were acquired for the purpose of carrying out representative applications generally undertaken by statistical offices. A full range of compilers, interpreters, and packaged software was obtained to support these activities.

#### 3.2.1 Godbout CompuPro System

Requirements for the more powerful of the two microcomputers included 8-bit and 16-bit processing capability; random access

memory (RAM) expandable to 1 megabyte (MB); 8" double-sided, double-density disks; communications capability; graphics capability; availability of BASIC, COBOL, FORTRAN, and Pascal language processors; and a variety of software packages. Desirable system characteristics included the ability to run the CP/M family of operating systems, a standard means of transferring information and signals (bus), a fast execution speed, reliable local vendor representation, potential support for the Motorola 68000 microprocessor chip, and the capability to support a 9-track, industry-compatible tape drive.

At the time this system was procured, the equipment which met the most of these selection criteria was produced by the CompuPro Division of Godbout Electronics. The CompuPro system procured was customized to comply with definite specifications. The resulting microcomputer system contained 448 kilobytes (KB) of RAM, an 8085/8088 dual processor board, a CPU 86/87 board with an 8087 math chip, an Interfacer 4 board, a multiplexer board, and Disk 1 and Disk 2 boards. In addition, it had two 8" floppy disk drives, a 20 megabyte (MB) Winchester disk, a high-resolution green video monitor, a Televideo 925 terminal, a Televideo 950 terminal, and a 15" parallel/serial printer with a 15" carriage.

A large repertoire of software was available for the CompuPro system. The more noteworthy packages included: CP/M-80, CP/M-86, and MP/M 8-16 operating systems; CBASIC-86, MBASIC, MBP COBOL, FORTRAN-80, Pascal/MT+86, and C language processors; dBASE II, Microstat, ACCESS/80, SP-MICRO, STATPAK, SuperCalc-16, and WordStar applications software packages; and TERM II communications software.

### 3.2.2 Apple II+ System

The smaller of the two microcomputer systems had quite different requirements. It was to be a common system widely used in developing countries and having an abundance of software available; color graphics capability BASIC and Pascal; and a low cost.

The Apple II+ computer was chosen because it met all the criteria and was especially prevalent in developing countries. The basic 48KB system was augmented to include 64KB of RAM, 2 5-1/4" floppy disk drives, a 20MB Winchester disk, shift key modification to allow for upper and lower case, an 80-column video screen, a serial asynchronous interface, a PKaso Parallel Graphics Interface card, a color video monitor, and a dot matrix printer.

Software procured for the Apple was somewhat more modest than that acquired for the CompuPro system. It included the DOS 3.3 and CP/M 2.2 operating systems; BASIC and Pascal language processors; ISIS (Integrated Statistical Inquiry System) and Apple II Business Graphics application software packages; and PTERM communications software.

### 3.3 Applications Undertaken

A number of diverse applications were chosen for implementation on these microcomputer systems. They were selected on the basis of their utility within statistical offices for all facets of data processing and the likelihood of their implementation by typical statistical office personnel.

#### 3.3.1 CompuPro Applications

Microcomputers are well suited to processing surveys of moderate size and complexity. In many cases developing countries already have software designed for some aspects of survey processing on mainframe computers. The ability to convert this existing software could be very important to initial savings of time and money.

To test the feasibility of mainframe-to-microcomputer software conversion, an application was designed to use the CompuPro to process a 600-questionnaire survey taken in a developing country in Asia. The processing had previously been done on an IBM mainframe computer using COBOL and FORTRAN programs. The programs and data were downloaded from the mainframe computer to the microcomputer using a modem and communications software.

The conversion effort was minimal and the execution times were surprisingly fast. The greatest deficiency was the lack of a tabulation package comparable to ISPC's CENTS 4 package used on the mainframe. As a result, the tabulations had to be custom coded in COBOL in order to match completely the mainframe output. These efforts, although not highly demanding in terms of time, required a programmer with extensive knowledge of COBOL and FORTRAN.

An alternate approach to processing the data from this survey was taken by using packaged software. The data were formatted to satisfy the requirements of the data base management package dBASE II. The commands provided under dBASE II facilitated editing the data with the same criteria applied using the customized COBOL programs. Tabulation of the data was accomplished using ACCESS/80. The tables were not in a format suitable for publication; however, the numbers were correct. The variances produced using a FORTRAN program could not be duplicated using packaged software because of the complexity of the sample design used in the survey. In general, this approach demonstrated the effectiveness of user-friendly packaged software in meeting at least some of the needs of survey processing. This type of software facilitates data processing by users who know the data, but do not necessarily have the skills for writing input/output routines or other data management routines in a high-level programming language.

A variety of statistical analysis software was examined using the CompuPro system. Although many of the packages were user-friendly, some to the point of being slow because of the amount of interactive communication with the user, most of the packages showed serious deficiencies in overall performance. However, the

package "SP-MICRO" was quite effective in providing a subset of the statistical routines available under SPSS on mainframe computers.

Notations compiled while reviewing microcomputer literature were put into a dBASE II file using the keyword system mentioned in section 3.1.2 above. This file proved to be an invaluable tool while writing this document.

Office administrative support activities were undertaken using packaged software. SuperCalc was used to generate and modify project budgets. WordStar was used for entering and editing a major part of this final report. Both packages were used successfully by persons with little data processing experience.

### 3.3.2 Apple II+ Applications

The ISIS package was used to enter data from a small agricultural survey consisting of 150 questionnaires. The package was enhanced to allow range editing during data entry. The data were tabulated using the statistical routines available under ISIS and the results were shown to match those generated by mainframe tabulation software. The ISIS package, while extremely user-friendly, was found to have severe limitations in terms of the number of cases it can handle and its lack of editing capability.

A screen-oriented system was written in Pascal as a prototype for processing foreign trade data at the customs site where commodities enter the country. This type of distributed application has the potential to alleviate the bottleneck that occurs in the central office and to improve the quality of the data by placing the data entry at the site where the information is recorded. A portion of the system incorporates color graphics to summarize the import commodities recorded using bar charts and pie charts. The system allows for the operator to have no data processing experience; the operator simply follows the instructions which appear on the screen.

## 3.4 Comparison of the CompuPro and the Apple II+

Although extensive parallel processing to compare the performance of the CompuPro and the Apple II+ microcomputers was never intended, several observations can be made in way of comparison of the two machines. The differences concern price, user community, support, mode of operation, speed, memory, and potential applications.

The Apple II+ hardware was considerably less expensive at $8,400 as compared to $16,250 for the CompuPro hardware. This cost difference was indicative of two distinct levels of sophistication and capability.

In working with the vendors to make the microcomputers operational and to install software, it quickly became apparent that the user community and support for the Apple were much greater. Large CP/M user groups exist in major U.S. cities and these would certainly

include CompuPro users who run the CP/M operating system; however, most people have never heard of a CompuPro microcomputer and CompuPro user groups are virtually nonexistent. Apple microcomputers, on the other hand, are so popular that user groups abound. Whereas there is only one dealer authorized to provide CompuPro service on the East Coast, Apple dealers who can officially provide service are far more numerous.

The mode of operation of the two microcomputers is distinct in that the Apple is a single-user machine, whereas the CompuPro can support multiple users simultaneously. Although the CompuPro was usually used by one peron during the course of this study, there were times when it was very advantageous to have the multiuser capability.

The only true comparison of the microcomputers' performance was to run the prime number producing benchmark program written in Pascal and published in BYTE magazine on both machines. It revealed a significant difference in the speed of the two microcomputers with the CompuPro completing the benchmark more than 10 times faster than the Apple II+.

The differences in speed and memory size (Apple II+ having 64KB and CompuPro with 448KB) suggest that the CompuPro is a better machine for applications that require fast execution or involve large data files or programs. The memory limitation of the Apple, in particular, is quite restrictive.

The two microcomputers were not significantly different in terms of software cost (per package), ease of use, and reliability. Most software packages fall in the $200 to $500 range. With minimal instruction, users were able to become productive quite quickly. The only maintenance necessary over a year's time was a board modification for the CompuPro to allow the multiuser operating system to function correctly and a board repair on the Apple II+ to replace a damaged chip.

The two microcomputers were obtained with different intentions. None of the points of comparison listed above came as a surprise.

## 4. Summary

The knowledge and actual experience gained through the course of the project, in combination with the reports of other microcomputer users, provided a sound basis for this document. It covers a wide variety of microcomputing topics and considerations for the use of microcomputers in developing countries.

Hopefully, the document will be of use to a widespread audience; in particular, to future microcomputer users in developing country statistical offices. In order to assist the reader who has particular needs, a special interest directory is provided to highlight certain chapters.

## 5. Future Activities

It is important to look beyond this project at what developing country NSO's need in the way of support in addition to this document. Several areas of support deserve mention.

Developing countries will need guidance in microcomputer system selection and procurement beyond that available through local vendors. They need the advice of unbiased experts who are current with the technology. This would involve at least an assessment visit, and possibly several followup visits to see the procurement and installation to completion.

Training in the use of microcomputers would go a long way to assure their success. Courses covering operating systems, use of specific packaged software, techniques for custom programming, and trouble-shooting would certainly help new users get started. The courses should be designed to include a workshop component and should be well documented.

As usage of the microcomputer(s) increases, questions and problems are bound to arise. An information clearinghouse for microcomputer users could alleviate much of the current frustration that now exists when developing country microcomputer users find themselves in isolation without answers and solution. Such a clearinghouse could serve multiple functions:

- -- To answer specific user questions.
- -- To make software recommendations.
- -- To put users in touch with other similar users, ideally in their region of the world.
- -- To circulate technology updates in the form of a newsletter or other periodical.

The clearinghouse would have to be sufficiently well staffed to maintain expertise in numerous areas and a current data base of users by region.

New users may feel they need more substantial technical assistance to tackle new applications. A source of such technical assistance capable of dealing with multiple microcomputers and software packages and ideally with experience in a variety of application areas should be identified. The level of assistance would depend on the complexity of the application and the experience of the users.

In support of statistical data processing, editing and tabulation software for microcomputers must be developed. These software packages may initially be adaptations of mainframe software packages, but ultimately should be redesigned to take advantage of microcomputer capabilities. The development of this type of software is a necessity before large-scale processing of surveys and censuses can be done effectively on microcomputers.

Finally, this document should be updated periodically to reflect changes in microcomputer technology. The sections on specific hardware and software will quickly become outdated. New valuable case studies will emerge. Readers of the existing document will have worthwhile suggestions of additions and modifications.

It is important that donor agencies focus on at least some of the aforementioned suggested activities which have the potential to affect multiple developing country users. Their support will greatly enhance the successful institutionalization of microcomputing technology.

# CHAPTER 1: INTRODUCTION

Large mainframe computers are available within the government sector of most developing countries. However, statistical data processing is often hampered by the problems typically associated with mainframe computer centers. These machines are frequently used for time-consuming tasks such as payrolls, tax collections, and national accounts, thus restricting access for other purposes. Computer center management problems can result in lengthy turnaround time. The requisite personnel for supporting hardware and software are often scarce or non-existent. The greatest problems involve maintenance of the equipment. Equipment failure can completely disable the system and, if replacement parts are not available, users can experience long delays.

National statistical offices (NSO'S) in developing countries must respond to the need for statistics from censuses of industry, agriculture, population, and housing; from foreign trade records; and from household and other sample surveys. These activities are generally processed utilizing mainframe computer resources and peripheral data entry devices. Support activities, such as word processing, spreadsheet preparation, graphical analysis, and data base management, are often urgently needed but not yet computerized in developing countries. Thus, computing needs are broad in scope. The data which result from censuses and surveys must be timely in order to be useful for policymaking. The outputs are generally restricted to tabular and textual presentations. With few exceptions, statistical activities suffer from budgetary restrictions since their funding is derived solely from the government and statistics usually have low priority.

Microcomputers offer an alternative to mainframe computing which addresses many of the problems outlined above. They are inexpensive in comparison with mainframe computers; for under $5000 an entire system can be purchased. Use of microcomputers in a distributed environment enhances accessibility and turnaround. System support is on a completely different level and does not require the customer engineer that services mainframe computers. New approaches to data presentation are facilitated by graphics capability. Although the microcomputer places a greater degree of responsibility on the individual user, it also affords him a flexibility not obtainable with mainframe computers.

Microcomputers have, in fact, already begun to appear in developing countries. These machines are typically the least expensive models which are purchased as off-the-shelf systems, meaning that no customization is needed. They are generally being used for a specific application, such as word processing, and thus have a limited software repertoire. Local service is being offered by several of the more popular companies in the large cities of developing countries.

The International Statistical Programs Center (ISPC) of the U.S. Bureau of the Census has had a long history of working with

developing countries. This work has included developing generalized software to aid in processing statistical data and giving training and technical assistance in support of a wide variety of census and survey activities.

As the microcomputer revolution became increasingly more apparent, ISPC felt compelled to make a statement on the appropriateness of microcomputer technology for national statistical offices of developing countries. Staff were being urged to consider microcomputers instead of mainframe computers in developing project papers for the U.S. Agency for International Development (AID). It became obvious that someone needed to study the feasibility of this alternative computing resource in order to be able to make sound recommendations. AID agreed to fund such a study with the following major objectives:

-- To study microcomputing technology in order to assess the capabilities of existing hardware and software, understand the microcomputer marketing approach, and learn of trends for the future.

-- To assess the current and likely future availability of microcomputers, microcomputer software, and associated support in developing countries.

-- To acquire one or more microcomputers with the intention of doing processing typical of that of a national statistical office.

-- To explore the limitations of microcomputer technology and potential problems for the microcomputer user in a developing country.

-- To present guidelines for the selection, institutionalization, and use of microcomputers in developing countries.

The interest of this study is not to suggest the elimination of mainframe computing, but rather to identify appropriate uses for microcomputers. It is recognized that certain tasks, by virtue of their size or computing requirement, are simply not good candidates for this new technology. This report will, therefore, attempt to describe environments which take advantage of the strengths of both mainframe computing and microcomputing.

From the outset of this study, it was recognized that microcomputer technology, as a new technology, was not a panacea to solve everyone's problems. In fact, it comes with its own set of problems, many of which can prove extremely frustrating. This study will attempt to present a realization and objective picture of microcomputing, not necessarily in the context of a high technology environment such as one would find in a large metropolitan area of the U.S., but rather in the environment of a developing country. Actual examples as reported by microcomputer

users around the world will be used wherever possible to substantiate the points made throughout this report.

The audience for which this report is intended covers a wide variety of people. There is no requirement that the reader be a technical person. An attempt has been made to write the text of this report without jargon and to provide a glossary for the necessary technical terms. This report can serve to meet the needs of many different readers. Hopefully it will be useful to the AID officer trying to become computer literate, to the expert technician attempting to provide assistance to developing countries, to the host-country national assessing the appropriateness of microcomputers for his agency, and to the student following a data processing curriculum. Unfortunately parts of the report will be out of date the day after they are written, but the discussion of microcomputer philosophy and general guidelines should remain current for many years to come. An attempt will be made to periodically update those sections subject to change.

# CHAPTER 2: THE TYPICAL NATIONAL STATISTICAL OFFICE

In order to assess the potential for microcomputers in NSO's of developing countries, it is necessary to depict the current situation in these offices, in terms of hardware, software, physical environment, staffing, mode of operation and applications. It would be impossible to address every combination of these components; therefore, a typical case will be described to orient the reader to the ensuing discussion.

## 2.1 Hardware

The typical NSO has an IBM 370/115 mainframe computer with 256 kilobytes (KB) of primary memory, two disk drives each holding 70 megabyte (MB) removable disk packs, one 600 line per minute printer, a card reader, a diskette reader, and two tape drives. This system is leased at $8000 per month, including maintenance.

There are five IBM 3742 dual-station key-to-diskette devices for data entry. Five IBM 029 keypunches are available to the programming staff for program development.

## 2.2 Maintenance

Preventive maintenance is performed on the computer each week, making it unavailable for several hours. Additional service calls are sometimes necessary. The problems can often be remedied the same day, but if parts are not available, the machine remains "down" until parts can be sent.

Maintenance of the key-to-diskette devices is less critical because there are multiple stations. However, it seems that at least one station is always disabled or not functioning as it should.

The IBM 029 keypunches are no longer under maintenance contract. Instead, parts are cannibalized from several "cadavers" whenever one breaks down.

## 2.3 Software

The IBM 370/115 operates under the DOS operating system. COBOL, FORTRAN, and RPG II compilers and an IBM/ALC assembler are available. SORT/MERGE and standard file maintenance utilities are also provided. The only generalized software packages installed on the machine are the COCENTS tabulation package developed by ISPC and SPSS for analysis.

## 2.4 Environment

Extremes of temperature and humidity combine with a poor air conditioning system to cause frequent operational problems. Voltage variations and power outages due to electrical storms and weaknesses in the source of electricity are responsible for numerous system failures.

## 2.5 Personnel

The data processing personnel consist of the following positions: chief of data processing, assistant chief for systems analysis and programming, assistant chief for operations and data entry, one systems analyst, eight programmers, one systems programmer, four computer operators, and 20 data entry operators. It is difficult to find good programmers and systems analysts and even more difficult to keep them. Because of their low salaries many employees accept their positions primarily to receive the training and experience which allow them to secure better jobs in the private sector.

## 2.6 Mode of Operation

All work done on the IBM 370/115 must be channeled through the data processing staff. Subject-matter specialists work with the systems analyst to develop specifications for programs which are then assigned to a programmer when one becomes available. All program development, testing, and production processing is done in batch mode with an average of 1-day turnaround on each run submitted. The workload of the computer center can be broken down as follows:

| By number of jobs | By percentage of time |
|---|---|
| 50% compiles | 55% execution - production |
| 30% execution - testing | 25% utilities |
| 10% execution - production | 15% exeuction - testing |
| 10% utilities such as SORTS | 5% compiles |

Users suffer great delays during the 4th week of each month when the government payroll largely occupies the computer. Data entry becomes a bottleneck area during the height of any major effort, such as a national census. There are frequent complaints of tapes being mounted incorrectly, card decks being lost, and priority for running jobs being given based on whom one knows.

## 2.7 Activities

The primary purpose of the NSO is to produce statistical data for use by other government agencies. To a lesser degree, analysis of the data is performed to support policymaking. Descriptive reports are produced to make these data available to those who need them. The subject-matter fields of interest are quite diverse, including population, housing, labor force, agriculture, industry, and foreign trade. The data processing staff are involved in the entry, editing, and tabulation of these data, as well as the generation of other statistics such as estimates of variance.

There are other activites within the NSO which are in support of the production of statistical data. Word processing is currently done on standard typewriters. Two photocopy machines are available. All official documents are photo-offset and are printed at a central government printing office. A separate department manually prepares graphics needed for publications or posters. Budgeting is done by hand by individual departments on spreadsheet

forms. Project monitoring is done haphazardly and the form it takes is completely up to the individual manager.

## 2.8 Major Applications

The greatest demand for data processing is generated by decennial housing and population, agriculture and economic censuses. Each census is distinct from the others in its particular characteristics. Specifics are provided to orient the reader to the volume of data processing work in an NSO.

The housing and population census collects data from 3,500,000 households, generating an average of 6 data records with 125 data cells per questionnaire. The data are primarily 1-digit fields and are maintained in fixed-field format. The geographic disaggregation is 5 regions or 25 provinces. Sorting of the data is required. Approximately 10 passes of the data are necessary to prepare the data for tabulation and further processing. Data editing is largely automated, with only a limited review of error cases. One hundred tables are produced. An additional 10 passes of the data are necessary for tabulation and analysis.

The agriculture census collects data from 500,000 producers. The questionnaire has 400 data cells, of which an average of 150 are filled. The data range from 1-digit responses to large numbers. They are disaggregated into 5 regions or 25 provinces. Sorting of the data is necessary. The data are passed approximately 15 times during editing and imputation. A combination of manual and machine editing is used. The agriculture census generates 150 tables. Roughly 15 passes of the data are needed for tabulation and analysis.

There are some special problems to be dealt with in processing agriculture census data. Quantities and weights must be converted to standard units. If part of the data is collected as a sample, it must be weighted. Large matrices are needed to supply information for checking yields and imputing missing data. Historical data is a necessity if the data are to be properly edited.

The economic census comprises 5,000 construction questionnaires, 5,000 manufacturer questionnaires, and 50,000 wholesale/retail questionnaires. Each questionnaire contains roughly 500 data cells, of which 150 are filled. The data are a mixture of 1-digit responses and large numbers. They are disaggregated into 6 urban areas and a rural balance. Sorting of the data is necessary. The data are passed approximately 10 times in preparation for tabulation and analysis. A combination of manual and machine editing is used. Successful editing requires the use of historical data in large matrices. One hundred tabulations are produced, requiring 10 passes of the data.

The national censuses are staggered so as not to overlap. However, the processing of each takes several years to complete.

An important activity of the NSO is the generation of foreign trade statistics on a quarterly basis. There are approximately 125,000 transactions yearly with 20 cells per transaction. These data are collected at 5 ports, 2 airports, and 15 border control stations. The data are a mixture of 1-digit responses and large numbers and are maintained in fixed-field format. Sorting of the data is required. The data are passed roughly 6 times during editing and imputation. A combination of manual and machine editing is used. Error resolution is particularly difficult because of the distance from the information source. One hundred tables are produced quarterly, requiring 10 passes of the data. The foreign trade system gets more backlogged with each passing quarter. The data are currently published 9 months after their collection, allowing little impact on policymaking.

Special surveys are conducted on an ad hoc basis as data are needed and money is available. If small amounts of data are involved, the editing is largely manual. The smaller data bases are more often subjected to statistical analysis than larger data files like the censuses because they are more manageable.

Monthly processing of the government payroll is an important application. Before checks can be issued, approximately 500 update transactions, affecting an average of 10 fields per transaction, must be made. The alphanumeric data are maintained in fixed-field format and represent employees in 10 government ministries. Sorting of the data is required. The data must be passed two times before printing the 10,000 checks and the accompanying accounting information for each ministry.

Administrative data bases are kept by the NSO. These are used for such things as determining promotion eligibility, maintaining furniture and supply inventories, and recording identification for magnetic tapes in the computer tape library. These data bases are maintained as sequential tape files, which are periodically updated and used for report generation.

In addition to these predictable activities, there are numerous miscellaneous requests for processing smaller quantities of data and producing tabulations. These sometimes receive the highest priority because they are urgently needed by someone at a high level.

Additional activities have been proposed. These include a continuing quarterly household sample survey, computerized sampling frames, and installation of a data base management system for manipulating summary statistics.

Most applications programs are now written in COBOL. However, prior to 1975, RPG II was more widely used; therefore, some of the older systems still include RPG programs. FORTRAN is used for statistical work such as calculation of variance estimates.

## 2.9 Problem Areas

The following problem areas are enumerated in priority order:

- -- Access to the computer;
- -- Hardware failures followed by delays in repair;
- -- Rapid personnel turnover with subsequent need for training new personnel;
- -- Management of the computer center;
- -- Cost involved in equipment rental and maintenance;
- -- Electrical failures;
- -- Printer speed;
- -- Reliance on cards for program development;
- -- Insufficient number of disk packs;
- -- Scarcity of packaged software; and
- -- Lack of technical documentation in the country language.

# CHAPTER 3: BRIEF HISTORY OF COMPUTING

It is both interesting and informative to look at the history of electronic computing and how the microcomputer was spawned. It is not simply an evolution of hardware, but rather an intricate combination of hardware, software, processing environment, and computer users that has grown and changed over time.

## 3.1 Evolution of the Microcomputer

Civilization has had computer technology for only several decades. The first electronic digital computer, the ENIAC, was developed at the Moore School of Engineering, University of Pennsylvania, in 1946. At that time experts claimed that some day a few large computers would probably handle all of the computational needs of this planet.(1) Today International Data Corporation estimates that the number of worldwide mainframe computer sites alone exceeds 105,000. Furthermore, International Data Corporation estimates that there are approximately 979,000 desktop computers worldwide and that about 53,000 units will be sold each month.(2)

The ENIAC generation consisted of banks of vacuum tubes filling an entire room and demanded an air conditioning plant of equal size. Their memories were not large enough for much else than crunching through large computations and cracking codes. They grew through the 1950's, but computers were not widespread until the invention of transistors in the 1960's enabled them to escape the limits of size, reliability, and the requirement for a special environment imposed by the use of tubes.(3) The semiconductor companies, led by Texas Instruments created a new idea in the integrated circuit, which fabricated several transistors at a time on the same silicon surface. The 1970's saw the incorporation of thousands of integrated circuits on a single silicon chip to form an entire central processing unit (CPU) equivalent in power to the ENIAC. This was the birth of the microprocessor, the heart of the microcomputer.

## 3.2 Three Generations of Microcomputers(4)

### 3.2.1 First Generation Microcomputers

A company called MITS introduced the first commercially successful microcomputer in 1975. The MITS Altair 8800 was based on the Intel 8080 CPU chip and used an internal bus developed by MITS, later to become known as the S-100 Bus. The Altair was sold for $400, as a kit for hobbyists, by a tiny New Mexico company. The firm was nearly bankrupt when it marketed its kits, and needed to sell 800 during 1975 to meet its financial obligations. It sold some 2,000 and continued to expand until it was bought by a larger company in May 1977 for $6 million.(5)

Though not many realize it, almost every aspect of the personal computer industry had its beginning with this single development. This includes the first computer to ever be offered in kit form,

the first personal computer BASIC and other high level languages, the first personal computer convention, the first personal computer publication, and the first software publisher for microcomputers.(6)

Between 1975 and 1977 a number of other manufacturers announced low priced microcomputer systems. IMSAI came out with an 8080 based computer which was directly competitive with the Altair 8800. Southwest Technical Products, introduced the SWTP 6800 which utilized Motorola's 6800 chip.

These computers and a few others constituted the first generation of microcomputers. They were targeted at the hobbyist and were usually available in kit form or assembled. The price for the basic CPU box with limited memory was under $1000. Few peripherals were available and most systems used magnetic cassette tapes for program and data storage.

Three things were lacking before the microcomputer could receive wide acceptance:

-- Some kind of low-priced, reliable, random-access storage;
-- A wide variety of useful software which was low priced and "user friendly"; and
-- Better customer support for hardware, software, and general information.

### 3.2.2 Second Generation Microcomputers

The advent of low-priced, 8-inch floppy disk drives paved the way for a second generation of microcomputers. In 1976, when floppy disk drive prices fell below $1000, they became attractive for microcomputer use. Shortly thereafter, 5-1/4" mini-floppy drives were introduced at prices of about $500. The floppy seemed to be the perfect storage medium for microcomputers.

In 1976, Apple Computer Inc. introduced the Apple I, the first microcomputer which could be purchased, installed, and used like an appliance. The product was fully assembled and ready to run. Soon after, Apple came out with the Apple II, which has sold more units than any other microcomputer. Apple's success was not based on technical superiority, but rather on marketing strategy. Apple boasted "complete microcomputer solutions." They were the first manufacturer to offer a widely distributed network of retail outlets supporting the Apple family of microcomputers.

Radio Shack, Commodore, and Ohio Scientific followed Apple by introducing inexpensive, floppy-based, small microcomputer systems. Each of these machines is based on a single 8-bit CPU chip, and has a CRT display screen with a keyboard. Each has a small operating system which supports file storage and program execution.

Along with products of Atari and TI (Texas Instruments), these microcomputers came to represent the "personal" end of the microcomputer spectrum. A great deal of recreational software is

available for each of them. In addition, there are small business systems designed to run on these computers.

The CP/M operating system, developed by Dr. Gary Kildall in 1972, is supported by most of the second generation microcomputers. On machines such as the Apple and TRS-80, CP/M is implemented as a secondary operating system, sometimes requiring a special CP/M board. There is a great deal of software available to run under CP/M, most of which can be classified as business software.

The second generation of microcomputers brought storage and software to their users. Customer support became more readily available; however, many of the persons employed by retail stores were only superficially knowledgeable. Over a million of these machines are in use today with new second generation systems being announced regularly.

### 3.2.3 Third Generation Microcomputers

Recent hardware developments, including 16- and 32-bit microcomputer CPU's, cheaper RAM memory, and auxiliary devices with greater storage, have ushered in a third generation of microcomputer systems. Three microcomputer chip families are predominating:

-- Intel's 8086,
-- Zilog's Z8000, and
-- Motorola's 68000.

Other powerful chips are under development.

The new microcomputer CPU's have larger address spaces, more powerful instruction sets, higher speed, and far more arithmetic power than their 8-bit predecessors. The combination of these features, larger RAM memories, and an order-of-magnitude increase in secondary storage volume via hard disks, leads to a computing environment rivaling that of today's small mainframes. The average cost of third generation microcomputers is between five and ten thousand dollars.

The major operating systems of the third generation are CP/M-86, MS-DOS, and UNIX, or derivatives of these. Expanded memory and increased production speed enable users to develop a larger percentage of applications using high level languages like C and Pascal. Applications software will become more sophisticated and will take advantage of improved man/machine interface facilities such as graphics, color, and hand-operated cursor control mechanisms.

Future trends for microcomputer technology include further miniaturization, more emphasis on networking microcomputers, lower prices, more powerful portable computers and terminals, and consumer pressure for standardization.(7)

### 3.3 Changes in Systems and Software

Progress can be appreciated when one looks at how systems and software have changed throughout the course of computing history. These areas are illustrative of the impact of microcomputers.

Computer hardware systems until the 1970's were associated with large air-conditioned rooms and multiple tape drives, disk drives, and printers. The advent of the minicomputer relaxed some of the environmental requirements and saw a decrease in size. The personal, desktop computer revolutionized this by virtually eliminating environmental requirements and providing stand-alone processing, store, and input-output for one user in a compact, desktop or smaller package.(8) It is now possible to make personal computers nodes of a local area network which allows users to share resources such as storage devices and printers.

Software has gone through a similar revolution. Programmers of the first computers took pride in actually writing in machine language, a code unintelligible to all but the elite. Then compilers such as FORTRAN and COBOL became widely used because they were much easier to learn and coding could be more readily debugged. With microcomputers has come a new set of languages which are interpretive, meaning that they execute code each time a source statement is encountered as opposed to creating an intermediate version of the program as a compiler does. (Mainframe interpreters have actually been around for many years, but interpreters have experienced a much greater popularity on microcomputers.)

In the early days, programmers generally wrote custom programs for each application. Then the utility of sharing code and writing generalized software which could be driven by different sets of parameters was recognized. This was the beginning of "packaged" software.

In the 1960's and 70's mainframe vendors such as IBM "bundled" hardware and software as a unit for marketing purposes. The naive user looked at the software as a sort of gift that came with his machine. In the mid-1970's "unbundling" became popular and, while it was billed as providing greater flexibility for customization, it was lucrative from a marketing standpoint.

Microcomputer programming went through a similar evolution, but it took only a few years for the exotic code of the hobbyist to be overrun by packaged solutions to almost every problem. However, for several years Apple, Tandy, Commodore, and their disciples did not market "software solutions," but rather left the job of creating a software repertoire to the individual user. CP/M gave the microcomputer user a large menu from which to select his software.

But now it's "back to the bundle" according to Hal Glatzer, an expert in the information industries. Adam Osborne was among the first people to start reversing the trend. He began to market a microcomputer with a standard keyboard, two 100KB disk drives, a

tiny CRT display, an operating system, two versions of BASIC, and packages to do word processing and generate spreadsheets -- all for under $1,800. The software alone, if bought separately, would cost two-thirds of that amount. But the marketing strategy sees increased volume of sales offsetting low profit margins on software.

### 3.4 Tangential Developments

It is difficult to say whether the successful evolution of microcomputers is a consequence or a cause of other advances in the computing industry and in computing practice. Some of the areas which come to mind are communications, new peripheral devices, decreasing costs, decentralization, and personalization.

Communication among machines of all sizes has become a reality because of standard interfacing techniques and improved telecommunications. This capability has alleviated the dependence on magnetic tape and other magnetic media which require peripheral devices and standard formats for program and data transfer.

New peripheral devices have changed the way work is accomplished. The use of cathode ray tubes (CRT's) has decreased the need for printed output by allowing the user to view programs or files on a screen. This has resulted in greater efficiency and economy because of the immediacy of the images, the saving of paper cost, and the ability to use slower printers because of decrease in demand. It should be noted that CRT's are commonly used as terminals to mainframe computers for the same reasons. Graphics terminals and plotters are common components of microcomputer systems, providing another medium of output. Floppy disks, as mentioned above, have provided an inexpensive means of data storage, with floppy disk drives being far more compact and costing only a fraction of the cost of conventional tape drives.

Computing cost can be considered to be made up of four components: the central processing unit and closely associated fast store; peripheral units for input, output, and auxiliary storage; operating and maintenance costs; and design and production of software. The cost of the central processor has been reduced by a factor of 100 as a result of the use of microprocessors in the central processor unit. However, the costs of the other three components have not experienced such a dramatic reduction. The overall impact is a cost reduction of roughly half for conventional computers. Moreover, a considerable amount of central processing can now be obtained for a few thousand dollars.(9)

The impact of microelectronics on computing methods is profound. Grosch's Law previously justified centralized computing on the economies of scale, stating that computing power varies as the square of the cost of the hardware. The introduction of inexpensive and yet powerful microcomputers has challenged Grosch's Law. The effect is one of substantiating a trend toward distributed processing; that is, the deployment of computerized data processing functions where they can be performed most effectively, at costs

usually less than those of other options, through the electronic interconnection of terminals, arranged in a network adapted to the user's characteristics.(10)

The important result is that users now have a choice: they can rely on the centralized mainframe computer, generally via a terminal, or they can work independently on a microcomputer, or they can mix and match these resources to fit their needs and their budgets. As Sandra Bertoli has termed it, this is "democratized" computer power."(11)

The personalization of computing raises all sorts of organizational and staffing issues. Decisions must be made concerning the organization of the hardware, the software, and the maintenance of hardware and software. Decisions have to be made concerning whether to employ specialist hardware/software persons in-house, whether to employ generalists who can do this work in conjunction with more general support, or whether to contract specialists for all the various requirements.(12) In the past, all the decisions described were made by full-time professionals in the computing center, acting on behalf of the user. Likewise, the computer operations staff undertook a total responsibility for all maintenance and operational activities. It cannot be stressed too strongly that in the new situation the user must take over all these roles unless there is some centralized support provided, which in turn involves problems of standardization.(13)

Programs were traditionally submitted as single step jobs on punch cards. Then it became possible to do multiple steps in one job, but cards were still the medium of communication. Terminals allowed this same communication to take place without cards and generally added an interactive communication interface. But most programs were still executed in batch mode, meaning that the user could not intervene until the process was completed. Data processing was cloaked in a mystique only penetrable by the initiated, the computer programmer or systems analyst.

Processing in a distributed environment and using microcomputers has gone a long way to change that image, popularizing such terms as user friendliness and menu-driven software. Programming and package execution are often interactive and many packages offer the positive reenforcement necessary to allow persons without a strong data processing background to use computers effectively.

### 3.5 Involvement of Developing Countries

The leaders of the computer industry have to date been the United States and Japan, with countries like the United Kingdom, France, and India playing smaller roles. Developing countries are really only just starting to feel the effect of the microcomputer revolution.

However, countries such as Hong Kong, Singapore, Korea, and Malaysia are capitalizing on the production of microcomputer

components. Other countries such as the Philippines and Brazil are looking to the development of national microcomputer industries.

## FOOTNOTES

Michael R. Radisch, Technical Computer Applications in Industry (Fort Collins, Colorado, 1980) cited by Thomas J. Boardman, "The Future of Statistical Computing on Desktop Computers," The American Statistician, Vol. 36, No. 1 (February 1982), p. 49.

2 P.J. McGovern (publisher), Review and Forecasting - Industry Report: Electronic Data Processing - Desktop Computers (Waltham, Mass.: International Data Corporation, 1980) cited by Thomas J. Boardman, "The Future of Statistical Computing on Desktop Computers," ibid.

3 Craig J. Calhoun, "The Microcomputer Revolution," Sociological Methods and Research, Vol 9, No. 4 (May 1981), p. 398.

4 Largely excerpted from a report prepared by Jeffrey Stone, a consultant to the World Bank, to support the Bank's Micro-computer Selection Study, 1981.

5 A. Osborne, Running Wild: The Next Industrial Revolution (Berkeley: Osborne/McGraw Hill, 1979) cited by Craig J. Calhoun, ibid.

6 David Bunnell and Eddie Currie, "The Age of Altair," Personal Computing, Vol. 1, No. 1 (March 1982), p. 89.

7 Jesse Berst, "The Latest Trends in Small Computers; What's Hot and What's Not," Interactive Computing (November/December 1981), p. 26-27.

8 Patrick Kenealy, "Personal Computers: a New Generation Emerges," Mini-Micro Systems, Vol. XV, No. 8 (August 1982), p. 165.

9 E.B. James, "Microelectronics: The Impact on Computer Centres," Computer Journal, Vol. 24 (February 1981), p. 9.

10 Felix Kaufman, "Distributed Processing," Data Base, Vol. 10 (Summer 1978), p. 10.

11 Sandra Bertoli, "The Utility and Potential Applications of Microcomputers in Data Processing and Analysis," report for the U.S. Agency for International Development (July 1981), p. 5.

12 James, Impact on Computer Centres, p. 11.

13 E.B. James, "Personal Computing Systems for Research and Development," (Imperial College, January 1981), p. 6-7.

# CHAPTER 4: INTRODUCTION TO MICROCOMPUTER TECHNOLOGY

Any treatment of so broad a topic as microcomputer technology in a document of this size is, of necessity, highly selective. In this section only those issues and topics that bear directly upon later sections of the paper or upon one or more of the findings and recommendations will be treated.

First, a definition of the microcomputer would be appropriate. Carol Anne Ogdin offers the following one in her book Microcomputer Management and Programming: "When the CPU (the combined control and logic units) of a computer is implemented in one integrated circuit (or a very small number of related integrated circuits), we call that device a microprocessor. When all five elements of a computer (Arithmetic Logic Unit or ALU, storage, input, output, and control) are combined together and the CPU portion is implemented as a microprocessor, the result is a microcomputer."(1) This definition clearly serves to delineate a class of computers based on the microelectronic technology employed.

## 4.1 Hardware

### 4.1.1 The Microprocessor Chip

The technological breakthrough that made the microcomputer revolution a possibility was the development of the microprocessor chip. This tiny device serves as the central processing unit (CPU) of the microcomputer, carrying out a carefully designed set of instructions, controlling the movement of data within the microcomputer system and performing arithmetic and logical operations upon data.

| Vendor | Microprocessor Chip | Microcomputer System |
|---|---|---|
| MOS Technology | 6502 | Apple II, Pet, Atari |
| Intel | 8085 | Compupro, Rair |
| Intel | 8088 | IBM-PC, Compaq, Victor 9000 |
| Intel | 8086 | Altos, Convergent Technology |
| Zilog | Z80 | TRS-80, Xerox, Osborne |
| Zilog | Z8000 | Onyx, Mao |
| Motorola | 6809 | Smoke Signal, Canon CX-1 |
| Motorola | 68000 | TRS Model 16, Sage, Apple LISA |

FIGURE 1. Currently Available Microprocessor Chips with Sample Systems Employing Them.

Figure 1 lists the most common microprocessors available in 1982 together with the names of representative microcomputer systems that have employed them. The first microprocessors to be widely exploited in the development of general purpose microcomputers have been 8-bit microprocessors. They are called this because they are

equipped to work with 8-bit bytes of data. Internal registers are able to represent and work with numbers as large as 256 (2 to the 8th power). More recent 16- and 32-bit microprocessors are designed to work predominately with 16- or 32-bit words (respectively) and have increased data regisiter size to make it possible, in a single processing cycle, to work with numbers as large as 65,536 (2 to the 16th power) in the case of the Intel 8086 and 8088 and 4.2 billion (2 to the 32nd power) in the case of the Motorola 68000.

Although the performance and characteristics of a microcomputer system are determined not solely by the microprocessor chip but instead by a complex relationship of many factors, the microprocessor chip is a particularly significant element in determining both. For example, the architecture and instruction set of a chip make it more or less difficult for system developers to implement operating systems, compilers and other system software. The size of data registers and paths over which data can be moved (the data bus) on the chip or to and from the chip influence the speed with which data can be processed just as the size of address registers and the address bus determine the amount of computer memory that can be directly addressed in any system that employs the chip.

New processor chips appear on the market with remarkable frequency. There is generally a delay of 2 to 3 years between the appearance of a new chip and the marketing of a fully-integrated microcomputer system making use of the chip. This delay appears, however, to be increasing as the complexity of the chips increases. As an example, industry analysts have been surprised at the time it has taken systems integrators to market systems based on the the Motorola 68000 chip, one of the most powerful and complex of the first 16-bit microprocessor chips.

As costs of these newer 16- and 32-bit microprocessor chips continue to decline, approaching those of the earlier 8-bit chips, it might appear that the newer chips would completely supplant their 8-bit predecessors. Debate has raged since the first appearance of 16-bit chips between users of well-established 8-bit microcomputer systems and those welcoming the newer marketplace entries. Defense of the 8-bit microprocessor has centered around the simple observations (1) that the vast majority of data processed by computers, specifically numerically encoded forms of alphabetic and numeric characters, can be most conveniently represented in a single 8-bit byte and (2) that the vast majority of data processing tasks of interest to individuals do not require large amounts of primary storage.

A similar debate may be predicted as 32-bit microprocessors begin to appear in fully integrated microcomputer systems. Fortunately, the developers of microprocessors have planned an easier transition for software developers as 32-bit systems arrive. Nevertheless, the 16-bit microprocessor's future may be determined in part by the length of time system developers and integrators have to work with

this generation of chips before a new generation of 32-bit microprocessors reaches the marketplace.

Although the possibility for variety is almost unlimited, most 8-bit microprocessor chips are equipped with a 16-bit address bus that make it possible for them to directly address 64KB of primary storage. The new 16-bit microprocessors have in most instances employed larger address registers and larger address buses. Both the Intel 8086 and 8088 are able to handle addresses consisting of 20 bits, making approximately 1MB of memory directly addressable; the two chips differ however in the size of the data bus. The Motorola 68000 employs a 24-bit address bus and can consequently address 16MB of memory.

4.1.2 The External Bus

Within each microcomputer system there must be a physical medium to provide for the transfer of data, addresses and control signals among system components. Generally, individual microcomputer system components are mounted on small fiberglass circuit boards. (In one standard, these boards are 6" by 9".) Each of these boards is fitted with a multipin connector that makes it possible for the board to fit into a plug within the microcomputer chassis called the "motherboard." The electrical paths that are established in this way and the protocol established for their use are called a "bus". All add-on boards attached to a microcomputer system (for such things as graphics displays, additional serial and parallel interfaces, or Winchester disks) must conform to the design protocol adopted by the system designers. For example, in adding a disk drive to the IBM Personal Computer, the control hardware for the disk must be mounted on a board that will fit within the IBM PC case and plug into the motherboard. Furthermore, the manufacturer of the disk drive controller must have used the connector pins in the way the IBM PC designers have specified if the device is to work.

Clearly, from the consumer's standpoint, a standard microcomputer bus would be of enormous advantage. However, there are numerous factors that argue against the wholesale acceptance of any standard and manufacturers have been reluctant to limit their flexibility in design. Manufacturers have offered bus designs to the industry for adoption as standards. Few, however, have received official recognition. Some designs are considered _de facto_ standards as a result of their widespread acceptance by manufacturers. The Apple II, for example, employs a proprietary bus that does not conform to any official standard, yet the great number of vendors that have marketed products designed for the Apple II bus contributes to its unquestioned status as a _de facto_ industry standard.

One microcomputer bus that has come very close to receiving official recognition as a standard is the S-100 bus. The design of this bus goes back to the very earliest microcomputer system, the Altair MITS. In 1978 the Institute of Electrical and Electronics Engineers (IEEE) established a subcommittee (P696) to study the S-100 design and to come up with an official standard. In July

1982 the draft of this standard was said to be very near completion though it had not yet been approved by the IEEE standards committee.(2) Despite the absence of an official standard for the S-100 bus, it is in an extremely strong position in the marketplace with no fewer than 50 firms producing S-100 board products.(3) According to Rodney Zaks, "in terms of numbers of users, the S-100 is without a doubt the most widely used standard in the computer industry."(4) The flexibility available with the S-100 based systems, makes the S-100 bus an attractive candidate for microcomputer integrators.(5)

### 4.1.3 Memory

The memory of a microcomputer is the physical medium that provides for the storage of data in such a way that it can be quickly and easily accessed by the central proccessing unit of the computer. Memory is sometimes referred to as primary storage (in contrast to secondary storage on disks or tapes that places data one step further away from the CPU). At this time, memory is one of the more expensive components of a microcomputer, and its cost is one of the areas in which dramatic advances can be expected. In most circumstances, the only question that arises with respect to memory is the quantity that is available with a given machine. There are, however, a number of issues relating to memory which should be covered. (A thorough treatment of all of these issues can be found in the book From Chips to Systems by Rodney Zaks.)(6)

Microcomputer memories are generally divided into two categories, random-access memory (RAM) and read-only memory (ROM). RAM and ROM are unlike in that RAM is volatile (that is, if power fails even momentarily, its contents are lost forever) while ROM is non-volatile. ROM is generally used for the storage of packaged application programs and operating systems. It can be purchased in forms that allow these programs to be erased or rewritten with appropriate equipment; eraseable programmable read-only memory (EPROM) that is sensitive to ultraviolet light is an example of this type of memory.

Microcomputer memories are for the better part composed of random-access memory. There are two major RAM technologies. The first of these is the dynamic metal-oxide semiconductor (MOS) technology, the second is the static MOS technology. Dynamic MOS tends to be the less expensive of the two technologies and it consumes less power. It has the disadvantage that it can retain its contents for only a very short period of time and requires special hardware to see that the content of every byte of memory is refreshed (read and then rewritten) at regular intervals. Attempts to access dynamic RAM must generally wait for the completion of these cycles, a requirement that can lead to problems both in speed and timing.(7) Static RAM does not require this refresh cycle but it is equally susceptible to power failures. It seems reasonable to assume that the power requirements and the cost of static MOS RAM will continue to drop in the future and static RAM will become increasingly the more desirable option for random-access memory.

Bubble memory, a technology that in the 1970's appeared to offer considerable promise, is slower than RAM and uses sequential rather than random access but has the great advantage that it is non-volatile and can be easily modified (unlike ROM). Bubble memory has not proven to be as fast or as low in cost as originally projected and the technology has been slow to develop. Three major American manufacturers pulled out of bubble memory production in 1981. Bubble memories are available, however, and have been utilized in recent microcomputer market entries. In one of these systems, the Bubcom 80, a 32KB memory cartridge was priced at $175 in mid-1982.(8)

All memories may be categorized by the smallest unit that is directly addressable. Memories may be bit-addressable or byte-addressable or, in larger systems, only word-addressable (where the word length may vary from 16- to 32-bits). It is important in selecting additional memory for a system to procure memory that is compatible with the system's CPU.

The amount of memory available on a microcomputer is primarily controlled by two factors, the size of the address bus that determines the number of addressable units that can be directly accessed by the CPU and the physical space provided for boards containing memory chips. Even though a system may be technically capable of addressing several megabytes of memory, if there are no available slots for the installation of memory boards, the size of the memory on the system cannot be increased. The density with which memory can be packed on a single board is steadily increasing (and this trend can be expected to continue), so the possibility of exploiting the capabilities of systems with limited physical space is improving. As an example, the IBM personal computer when it first appeared was capable of addressing 1.2MB of memory but the memory boards available could hold only 64KB and there were only 5 expansion slots in the system. Today there are boards available that will add 256KB of memory and utilize only one of these expansion slots.(9)

Some of the smaller and less expensive microcomputer systems available employ ROM as a major component of the machine's primary storage. The advantage of this is that an operating system as well as an application program such as a language processor or a specialized package can be immediately available in the system when the power is turned on. The disadvantage of this arrangement is that ROM is set at a precise location within the addressable memory of the microcomputer and this space is consequently unavailable for other uses even when the programs stored in ROM are not to be used. If the amount of memory available for a microcomputer is limited, the use of ROM will place even more serious restrictions on available memory.

Memories vary considerably in the speed with which they can be accessed. Within a given technology, faster memories generally cost more. The speed of memory can be important if additional memory boards procured are not fast enough to work with the CPU in the system being modified. Fast CPU's can be made to work with

slower memories by coding wait states for the CPU in the system software, though this is clearly an undesirable alternative. Memory access times vary considerably; for static RAM the range is currently 90ns - 450ns with 200ns being a typical speed.

Since many microcomputer system advertisements include some reference to direct memory access (DMA) it is worth adding a brief word about DMA. Normally all communication with memory requires the intervention of the CPU. This means that in every request for access to data in primary storage, from any of perhaps several system components, the CPU must stop what it is doing to pass the requested data to another device. This process takes time and can substantially degrade the performance of a system that has high input/output requirements placed upon it. To address this problem, a hardware device capable of retrieving data from memory without placing demands on the CPU and capable of responding to requests from other system devices is placed between the CPU and memory to facilitate DMA. If well implemented, DMA has the potential of dramatically improving the overall throughput of a system.(10)

### 4.1.4 Peripheral Interfaces

One of the thornier problems facing the microcomputer consumer is the variety of interfaces that may be used to attach peripheral devices such as terminals, printers, modems and even nine-track tape drives. An interface device provides the physical connection between the microcomputer system and the peripheral. It consists of a board containing the hardware necessary to communicate with the system microprocessor and to handle data that will be passed along to the peripheral device. The board plugs into the system motherboard and at least one other connector to which a cable joining the computer and the peripheral can be attached. Two common interfaces deserve treatment, the RS-232C and the IEEE-488 interfaces.

#### 4.1.4.1 The EIA RS-232C Interface

The RS-232C interface for the serial transfer of data over a single line is one of the older interfaces still in use and, according to one industry spokesman, one of the least understood.(11) The standard for the interface was set by the Electronic Industries Association (EIA) to accommodate data transfer between data terminal equipment and data communications equipment (a modem for example). Because the protocol for communication differs at the two ends of this exchange, with one end designated a "master" or talker and the other end a "slave" or listener, it is sometimes a difficult task to unravel the relationship between two RS-232 dependent devices. Signal names specified by the RS-232 are all defined from the perspective of the data terminal equipment (the "master"). Since most printers and CRT terminals are "masters", the computer itself acts as a "slave." When a modem, which is generally a "slave", is used, a special cable known as a null modem cable provides the wiring necessary to make the modem appear to be a "master" unit as well.

Data transmitted over the RS-232C interface are passed one bit at a time in serial fashion. A variety of protocols may be selected determining the speed of transmission (baud rate), the number of stop bits to separate groups of bits, and the use of a bit to mark parity. Despite all of the possibilities for confusion in the use of the RS-232C interface, it continues to be one of the most common of peripheral interfaces. It tends to be slightly more expensive than its parallel counterparts when supplied with a printer.

4.1.4.2 <u>The IEEE-488 Parallel Interface</u>

The IEEE's Standard Digital Interface for Programmable Instrumentation was "the first, comprehensive, nearly universal interfacing standard for computers and instrumentation."(12) The IEEE-488 standard (sometimes called the General Purpose Interface Bus or GPIB) provides for the transfer of 16 bits of data in parallel. It is sufficiently widely used that almost any type of peripheral may be found with this interface.

4.1.5 <u>Peripherals</u>

4.1.5.1 <u>Floppy Disks</u>

The flexible or floppy disk is the major form of secondary storage in microcomputer systems and has become standard microcomputer equipment for all but the least expensive devices. The disk was first introduced by IBM in 1973 and due to its low cost was an obvious candidate for magnetic storage medium when microcomputer systems developers began their work in the mid-1970's. The floppy disk is actually a thin, circular sheet of Mylar that has been coated with iron oxide and placed within a square plastic storage jacket. Until 1982 the disks were available in two sizes, 5.25 inches and 8 inches in diameter.

The floppy disk has the advantage that it is an inexpensive and reliable recording medium. The disks can be easily removed from the disk drive once recording has been completed and stored in a paper jacket for later use. The disks tend to have a life of more than one year if they are properly cared for.

Capacity of these small disks varies considerably. The earliest floppy disk drives of both the 5.25-inch and 8-inch disks began with relatively low recording densities. In time it was possible to double the density of data stored on the disk and finally to quadruple the amount of data stored by using both sides of the disk. The Qume DT-8, an 8-inch floppy disk drive, is capable of storing approximately 1.2MB of data in a double-sided, double-density format. The earlier 5.25-inch disk drives held considerably less data than an 8-inch drive; typically the disk would hold approximately 140KB. Advances in recording technology have led to dramatic increases in the capacity of these smaller disks. By mid-1982, Micropolis had announced a 5.25-inch disk drive capable of holding 2MB of data using a track density of 96 tracks per inch.(13) Clearly the capacity of floppy disks,

regardless of the size of the disk, can be expected to continue to increase.

The year 1982 witnessed the development of disk drives using even smaller disks. Sony now produces a 3.5-inch disk drive that uses a disk with a inflexible outer case. Hitachi, together with several other Japanese firms, has released a 3-inch disk drive which also employs a hard-shell disk design. A U.S. firm, Tabor Corporation, has introduced a 3.25-inch design that will utilize the traditional flexible disk design. There are industry spokesmen who are still optimistic that a single standard can emerge for these smaller disk drives; others predict that there will be increasing numbers of designs that will be commercially successful and all attempts to establish an industry standard will be unsucessful. The American National Standards Institute has formed a subcommittee to address the issue.(14)

Industry analysts predict that worldwide shipments of floppy disks will grow at an annual growth rate of 42 percent at least through 1984. The number of 5.25-inch disk shipments will outnumber that of 8-inch disks, but both are expected to have strong growth through 1984. With 5.25-inch disk drives the trend is clearly towards increased density of recording with higher density drives expected to capture 73 percent of the market by 1984.(15)

Since the floppy disk is a major means of transferring programs from software vendors and data from other microcomputers, one of the primary issues in the selection of a microcomputer system is the question of the compatibility of the floppy disk format. Ideally, a disk from one system could be inserted in a comparable drive on any other system and be read without difficulty. The reality, however, is far from the ideal. With single-sided, single-density 8-inch floppy disks, there is complete compatibility between systems using the CP/M operating system. The chances for compatibility are enormously reduced if different operating systems are involved. In addition, the use of double-density recordings further reduces the chances of compatibility between systems. With double-density 8-inch disks the recording format varies from one disk controller manufacturer to another. The situation with 5.25-inch disks is not nearly as tidy as that for 8-inch disks. Even with single-density recordings from a common operating system the chances are small that a 5.25-inch disk recorded on one system can be read in a system from another manufacturer.(16)

The development of disk reformatting software may partly address the problems of compatibility, but even when software is available the need for disk reformatting merely adds one additional hurdle to the task of transferring programs and data from one system to another. The problem of compatibility will be particularly acute in situations where no alternative to the floppy disk (such as a modem) is available for program transfer. In such situations, the microcomputer user may be completely dependent upon the microcomputer vendor (or other users of the same system) for packaged software.

Floppy disk drives vary in the speed with which they can handle data and system performance can be affected dramatically by these differences. Generally, faster head positioning and transfer rates are to be preferred. Comparing the speed with which several systems can handle the task of writing and then reading a hundred records can be an extremely informative exercise.

4.1.5.2 Winchester Disks

In 1973, IBM introduced a rigid disk drive that employed very light read and write heads and a lubricated disk contained in a dust-free environment to significantly increase the disks recording density and access speed. IBM had code-named the project "Winchester" and the name Winchester disk has accompanied the disk through almost 10 years of development. The capacity of the Winchester disks being manufactured for use with microcomputers is typically 5, 10, 20 or 40MB today although there are disks available with capacities as high as 1.5 gigabytes. Access times for these disks are approximately five times faster than those for floppy disks.

The Winchester disk was an immediate success when it was introduced to the microcomputer marketplace and as costs for the device continue to drop it will find increasingly widespread use. The advantages of increased storage capacity and speed will make possible the use of more sophisticated compilers and packaged software and will facilitate the management of large data bases on microcomputers. It is predicted that the value of worldwide shipments of these disk drives will reach almost $12 billion by 1984 with shipments of 5.25-inch fixed-disk drives alone reaching 644,000.(17) Further, it can be expected that the capacities of these disks will increase dramatically and that microcomputer systems will adopt the new technology.

Disk storage is already one of the more expensive elements of a microcomputer system. A 20MB Winchester disk drive is likely to cost between $3,000 and $5,000 in 1983, perhaps accounting for one-quarter to one-half of the cost of all system hardware. The cost of disk storage is expected to account for approximately half of the cost of most small business or professional microcomputer systems in 1987.(18)

Although Winchester disks are considered extremely reliable, their performance in environments with dirty power or harsh environmental conditions is undocumented. In addition, use of drives with such large capacity intensifies the problem of making backup copies of data and programs for safekeeping. Because the capacity of the Winchester disk is so much greater than that of the floppy disk, the floppy is not the most convenient backup medium. Streaming tape drives are sometimes available but must usually be offered as a package for the disk manufacturer if they are to be used sucessfully. In most cases, the problem of disk backup is simply not yet satisfactorily resolved. One potential solution to the problem is the use of two Winchester disk drives, at least one of which would contain a removable cartridge disk. Most drives

currently available do not offer removable disk cartridges, but there are several early market entries that do.

#### 4.1.5.3 Tape Drives

The oldest and still the least expensive media for data storage is magnetic tape. Traditionally mainframe computers have used reel-to-reel tape drives with 1/2-inch magnetic tape. As computer systems have become smaller, new tape drives using 1/4-inch tape in both cassettes and cartridges have been introduced. With microcomputers, tape drives are used primarily for bac ing up Winchester disk drives and for archiving data. Although tape drives themselves are generally expensive by microcomputer standards, the cost of storing data on tape continues to be lower than that for any other magnetic media.(19)

Tape drive operation is typically in one of two modes. The stop/start mode resembles the operation of tape drives on mainframe computers where individual records or groups of records may be separately read or written. The more common mode of operation for tape drives on microcomputers is the streaming mode in which large blocks of data are recorded on tape in the same order in which they have been taken from some other medium such as a disk or memory. Tape drives having start/stop capability might be used to store large data files during processing; streaming tape drives that cannot access data in a record-by-record manner could not be used in this manner.

##### 4.1.5.3.1 Cassette Tape Drives

The earliest and the least expensive of the tape drives available for microcomputers were audio cassette recorders. The devices themselves in almost every instance cost less than \$100 and the tape cassette is easy to handle and use. The cassette tape recorder, however, is an unreliable and an extremely slow storage medium. The least expensive devices are limited to data transfer rates of just 1KB per second and can store no more than 200KB on a single cartridge. More expensive drives (\$200 - \$1000) may boost the data transfer rate to 6KB per second and the cassette capacity to 1MB but these drives require more expensive cassette tapes.

##### 4.1.5.3.2 Cartridge Tape Drives

The cartridge tape drive has an impressive track record and an industry standard, developed for the drive by the American National Standards Institute (ANSI X3.55-1977). Cartridge tape shares with cassette tape the advantages of convenience, durability and low cost. The cartridge excels, however, in capacity and in speed of access. The devices cost in the range of \$700 to \$4,000 and have data transfer rates at the high end of those for the cassette tape drive (6KB per second). Operating in the stop/start mode the devices have an average access time of 20 seconds. Capacity is generally less than 10MB although it may be as high as 70MB. The cost of data storage is approximately \$1.70 per MB. The streaming

tape drive is generally used for Winchester disk backup and is designed to perform disk backup at high speed. The relative advantages of streaming to stop/start operation may not be as great as their proponents suggest.(20) Streaming cartridge tape drives are said to be the only devices available that sell for less than the Winchester disk they are used to back up.(21)

#### 4.1.5.3.3 Reel-to-Reel Tape Drives

The standard mainframe tape drive is a 9-track, reel-to-reel tape drive. Similar drives are available for microcomputers, though the price of the drives ($7,000 and up) make them an unusual addition to a microcomputer system. Reel-to-reel tapes have the lowest cost per recording unit of all magnetic media ($0.80 per MB) and a single tape may be capable of holding 20MB or more. It may be possible with reel-to-reel tape to maintain data transfer rates in the 100's of KB's per second.(22)

Reel-to-reel tapes tend to be much less convenient to use than cartridge and cassette tapes and the drives themselves, especially those employing a vacuum system, may require costly maintenance. They can, however, offer a reliable means of exchanging programs and data with mainframe computers and provide an exceptionally cost effective means of archiving large quantities of data.

### 4.1.5.4 Video Terminals

The video terminal generally serves as the primary link between the user and the microcomputer system.(23) It is able to encode keystrokes into sequences of ASCII codes that are in turn recognized by microcomputer system software. It is also able to receive a sequence of ASCII codes from the microcomputer and display them as alphanumeric characters on a video display. The normal mode of communication between the terminal and the microcomputer is a serial EIA RS-232C interface.

The video terminal market is one of the most competitive of all microcomputer component markets. There are literally dozens of manufacturers offering an even larger number of models. This situation is possible because of the enormous demand for the devices. It is predicted that U.S. shipments of video terminals alone will number more than 2 million units per year by the year 1985(24) with Applied Digital Data Systems, Televideo, Lear Siegler and Hazeltine together currently holding 63 percent of the market.(25) Prices range from $500 to $7,000, though a typical microcomputer terminal will cost less than $1,000 in 1983.

Video terminals employ displays of different colors. Black and white displays are equalled in number by green and black displays. Color terminals, too, are available, but due to the large memory requirements of these devices they are not widely used. A 12-inch screen is generally used, though 15-inch screens are becoming popular. Generally the screen will display 24 or 25 lines of 80 characters. There are terminals available that will display lines

of 132 characters (an extremely useful feature when preparing tabular reports) and those that will display 48 lines. Character sets vary from terminal to terminal and some are considerably more readable than others.

Keyboards, too, vary considerably in design and features. A full set of ASCII characters is desirable, as is a numeric keypad and additional function keys which can be used in well-integrated software. The extra keys required to accommodate a full ASCII character set should be placed outside the standard IBM Selectric keyboard arrangement. A detachable keyboard is an added convenience.

One of the major obstacles facing designers of packaged software is the difficulty of designing systems that can deal with the enormous variety of terminal protocols. Although there are industry standards, almost every manufacturer will depart from them in some detail. Even minor diversions from the standard can make the operation of packaged software a problem. Packaged software that makes use of terminal capabilities must deal with a number of different protocols. In many instances this number is limited and the use of other terminals may require custom modification of the software. As an example, the installation package supplied with the word processing package WordStar includes the following 17 terminal options:

Compucolor 8001G
Flashwriter I
Hazeltine 1500
IMSAI VIO
Lear-Siegler ADM-3A
Perkin-Elmer 550 (Bantam)
Soroc IQ-120
TEC Model 571
Visual 200

Beehive 150 / Cromemco 3100
Flashwriter II
Hewlett-Packard 2521 A/P
Infoton I-100
Lear-Siegler ADM-31
MicroTerm ACT-V
Processor Tech Sol
TeleVideo 912/920

Each of these terminals will employ different control characters or a different command sequence for such things as clearing the screen or placing the cursor. As stated in the manual, "if your terminal is not shown, you will need to consult the manufacturer's manual to determine its control codes for cursor positioning (and possibly for other functions), then 'patch' them in...."(26) Making the required software modifications is not always a trivial matter.

4.1.5.5 <u>Printers</u>

Although the microcomputer has moved its users away from the heavy reliance on printers that has been common in mainframe computing through the introduction of the video terminal, the printer is still an integral part of a microcomputer system. Printers are generally attached to the system through an EIA RS-232C serial interface or a Centronics parallel interface. Occasionally a printer will be capable of using either interface.

It is helpful to be able to set transmission rates and protocols for the printer using easily accessible toggle switches. Manufacturers provide for this in different ways and some are distinctly more difficult to manage than others. For example, the Okidata 82-A printer allows the use of either the serial or the parallel port that are provided as standard equipment with the printer. To switch between these two ports however requires a change in the setting of a switch that is located within the printer case. Access to the switch requires removal of paper and the platen before a screwdriver can be used to remove the printer case. The C. Itoh Prowriter, on the other hand, allows the use of either serial or parallel port without the requirement of adjusting a switch setting. The toggle switches used for selecting transmission rates and protocols are all within the printer case but are easily accessible from the outside.

Printers may be divided into several distinct categories among which there is considerable variation in speed and mode of operation.(27)

4.1.5.5.1 Dot Matrix Serial Printers

The dot matrix serial printer is the most widely used microcomputer printer largely because its cost is low ($350 and up). The dot matrix printer is generally capable of working at rates of 30 to 300 characters per second. It prints by forcing a selected pattern of needles from a rectangular array of needles to strike a printer ribbon and platen. The quality of characters produced may vary noticeably from device to device and is largely dependent upon the size and number of elements of the matrix and the design of the character sets used. Typically, dot matrix printers are able to support several different type pitches. Graphics capability is available, although the quality of graphics varies dramatically from device to device. Foreign language capability is expected to develop within this market. Color printers are available at prices under $2,000.(28)

4.1.5.5.2 Solid Font Serial Printers

Daisy wheel and thimble printers comprise a second major type of microcomputer printer. These printers are generally slower than the dot matrix printers and rarely exceed 55 characters per second; a rate of 35 to 40 characters per second is common. Solid font printers have the advantage that they produce "letter quality" documents comparable to those typed on a typewriter but they are considerably more expensive than dot matrix printers. Prices range from $800 to $7,000. These printers are not useful for the generation of graphics displays.

4.1.5.5.3 Other Printers and Plotters

Thermal, ink jet, electrosensitive and laser printers are all available with RS-232C or Centronics interfaces. Impact line printers are available with speeds from 240 to 2000 lines per

minute. Prices range from about $3,500 to $20,000. Color pen plotters are available, most at prices of more than $2,000.

### 4.1.5.6 Modems

Computer systems separated by considerable distance can often communicate data and computer programs over standard telephone lines using communications software and a hardware device known as a modem (which is a shortened form of the full name, modulator-demodulator). The modem may attach to the telephone system either through a direct attachment (which requires either a modular telephone jack or a custom attachment) or through an acoustic coupler (which allows a telephone headset to be attached to the modem). The modem will generally connect to the computer through an EIA RS-232C serial interface port, but this connection requires the use of a special null modem cable. Some modems, such as the Micromodem II from Hayes Microcomputer Company, have built-in RS-232C circuitry but this has the effect of making the modem microcomputer system specific.

Modems are designed to transmit and receive data at one or more transmission rates. The most common rate in the microcomputer world is 300 bits per second or 300 baud. Since a single byte is most often transmitted with two additional bits called "stop bits," this is equivalent to 30 bytes or characters per second. This rate of transmission is extremely slow and the popularity of 300 baud modems has been primarily due to the low cost of these modems and to the fact that modems employing acoustic couplers are limited to this rate. Modems capable of 300 baud transmissions use the Bell 103 protocol in most cases.

The second most common rate of transmission is 1200 baud or 120 characters per second. Modems capable of operating at this faster rate may cost 8 to 10 times more than the slower 300 baud modems. In addition, there are two different protocols used by 1200 baud modems, the Bell 212A and the Racal-Vadic protocols. In 1983, modems capable of transmitting with any one of the three protocols are available at a cost of approximately $900.(29)

Modems with automatic dialing and automatic answering capabilities are available at prices ranging from $250 - $1500.(30) The addition of these two features can make it possible for communications between systems to take place with the microcomputer unattended, a possibility that may introduce not only new communications opportunities but security problems as well.

### 4.1.5.7 Optical Mark Reading and Optical Character Recognition Devices

Both optical mark reading (OMR) and optical character recognition (OCR) devices are available for microcomputers and, as prices continue to come down and the technology improves, both hold considerable promise for data entry on microcomputers. Both

technologies still have limitations that may be severe in a given processing situation. OMR devices may require a high standard of precision in the alignment of control markings on printed forms and may be sensitive to the quality of paper used for printing. OCR devices generally still require characters typed with a carbon ribbon using one of only a few select character fonts for satisfactory performance.(31) Prices for OCR equipment start at under $7,000; OMR equipment is available for less than $1,500.

4.1.6 Local Area Networks

The most favorable environment for communications among several microcomputers or microcomputers and larger computers may be the local area network (LAN). LAN's support high-speed communication between computers and make it possible to easily share limited resources such as disk storage or printing capability. In a LAN, computers are physically connected by means of a cable that attaches to a LAN controller that, in turn, handles communication between the device and other devices attached to the network.

LAN technology is characterized today by uncoordinated, widely divergent and innovative development. Standards are expected but they have been slow in emerging. The IEEE 802 Local Area Networks Standards Commission is working to establish common interfaces and protocols to bring greater order to the LAN marketplace.(32) The current situation is clouded by the debate raging between supporters of baseband and the supporters of broadband technology. Baseband technology supports only one transmission (one channel) at a time and can manage transfers of only 10 million bits per second. Xerox's Ethernet is an example of a baseband approach to LAN. Broadband technology, on the other hand, is capable of supporting multiple channel operation and transmission rates of 20 million bits per second.

In the long wait for standards a number of microcomputer vendors have developed single-purpose LAN products sometimes known as Personal Computer Networks (PCN's). Among these products are CORVUS' Constellation and Omninet, Cromemco's C-Net, Digital Microsystem's HiNet, Nestar System's PLAN 4000 and Zilog's Z-Net. All of these products employ baseband technology. Transmission rates range from 480K bits per second (bps) for the CORVUS Constellation to 1 million bps for the CORVUS Omninet and 2.5 million bps for Nestar System's PLAN 4000. Both Cromemco and Zilog use the RS-232C serial interface. It is estimated that 12,000 PCN's were already in use in the U.S. by early 1983 compared with only 800 LAN's.(33)

The Xerox Ethernet LAN has received considerable attention from the IEEE Standards Commission and it promises to be widely used. The Xerox/Intel/DEC Ethernet V1.0 specification permits 1024 network stations to communicate over distances to 2500 meters at speeds of 10 million bps. Ethernet controller boards are currently available for the IBM PC and S-100(34) and Multibus systems.(35) It is anticipated that the controller will eventually be placed on a collection of chips.

### 4.1.7 Power Monitors and Conditioners

While not specifically microcomputer hardware, power monitors and conditioners may prove to be critical additions to a microcomputer system due to the sensitivity of some microcomputer components to power supply aberrations. Power line monitors are available that will help to identify the problems that plague the power system. Monitors produce a printout detailing the date, the time, the severity and the duration of every disturbance from spikes to power failure. Monitors are available for as little as $350 but costs may be well over $1,000.

Line conditioners and line protection devices help to control the problems that monitors describe. Passive filters are the least expensive and will suppress transients and reduce noise. Surge suppressors are also inexpensive and are designed to protect the computer system from transients and surges. Both devices may be desirable and are frequently used in tandem. A fast response time, low clamping voltage, and a parallel connection are all useful features of these power conditioners. Isolation transformers serve to reduce noise but do not take care of spikes or voltage fluctuations. Line conditioners that regulate voltage and reduce noise are available as electronic tap changers and constant voltage transformers. Costs for these power protection devices vary from less than $100 to over $1000.(36)

An uninterruptible power supply (UPS) offers the most complete power protection available. In addition to providing protection against spikes, brownouts, and noise, the UPS is able to prevent the interruption of computer processing when line voltage fails by supplying backup power from a battery. A UPS may be capable of responding to power failures in less than 4msec and of continuing to provide power for several hours.(37)

UPS's are available with either alternating or direct current input or output. Normally, alternating current is used for both. In many of these systems the battery serves as a large filter as well as a power backup since the battery is used to drive the output (the computer) as it is being recharged from the input (line voltage). UPS's designed in this way typically incorporate either wet-celled or gelled-cell batteries. Gelled-cell batteries are lower in cost but have smaller capacities. Prices for these systems range from under $1000 to several thousand dollars depending upon the amount of power the system is capable of delivering and the length of time that battery backup power is provided.

### 4.1.8 System Integration

Bringing component parts together into an integrated microcomputer system is a demanding technical task. Most of this task (but, significantly, not all) will be accomplished by the microcomputer vendor. Systems are rarely available in the precise configuration that the user desires and the integration of add-on devices to the system available from the vendor may prove difficult.

The relatively high cost of components in the early days of the microcomputer and the appeal of these small systems to hobbyists with an interest in the details of system integration led to a widespread practice of "unbundling" or sales of system component parts in any combination that the consumer wished. As the cost of components has come down, there has been a trend towards a return to bundling.

Off-the-shelf systems such as the Apple II or the IBM Personal Computer offer basic systems consisting of components that will make the system minimally operational. These basic systems may be inadequate for practical applications. The cost of adding the hardware and software equipment required for a particular application of the system may equal or exceed the original investment in the basic system.

Since these off-the-shelf systems are packaged as component parts, the consumer is generally required to complete the task of integration by attaching the different devices. Serial or parallel ports, monitors and floppy disks are among the more common components that must be added to the basic system. Although documentation varies in quality from vendor to vendor, it should never be assumed that even these potentially straightforward tasks will be uneventful for the uninitiated.

Although the unbundled approach gives the consumer considerably more flexibility in procuring only those items believed necessary, it may contribute to problems of incompatibility. As a microcomputer system grows through the gradual addition of component parts, new and quite unexpected incompatibilities are likely to arise. For example, one may have used the Apple Business Graphics package on an Apple II system for graphics work with considerable success. A decision to upgrade the Apple hardware to allow for 80-character lines and upper- and lower-case characters through the addition of a keyboard enhancer board may make the graphics software unusable except when the new board is disabled. Likewise, use of the software with a Winchester disk drive may be problematic.

The success of the portable Osborne Computer with its bundled approach has encouraged vendors to market more completely integrated systems. Some off-the-shelf systems are now sold with full complements of hardware and software making them immediately useful office tools at extremely competitive prices. The sometimes more limited flexibility in configuring the system and inclusion of unnecessary components is likely to be completely offset by the advantages of a well-integrated system design.

## 4.2 Software

The performance of a microcomputer system depends not only on its hardware but also on its software, that collection of microprocessor instructions that enables the computer to perform useful tasks. Although there have been impressive developments in

microcomputer software, software development has generally not been able to keep pace with hardware innovations. There is often a delay of months or even years between the appearance of a microprocessor chip or a new peripheral device and software to employ it.

Microcomputer software, for better and for worse, has inherited much from mainframe computing practice. Although software designers have tried to capitalize on the advantages of these small machines, they have generally failed to make the conceptual break with past practice that is called for. As an example, microcomputer software has picked up the practice of utilizing isolated layers of software in the design of systems. User programs to perform highly specialized tasks form one level of this layered design. The operating system with its information on how the user program is to be run forms another layer. Interactive features generally mimic the developments that occurred with the introduction of timesharing and provide little more than occasional breaks in a batch job at which time the user can direct further batch processing.(38)

Microcomputer software advertisements and literature are peppered with references to "user-friendly" software with "English-like" command structures or "menu-driven" operation. Not to belittle the strides that have been made in software design and implementation since software development for microcomputers began, most of these claims are overstated. It is extremely difficult to specify what precisely makes any system "user-friendly," and one user's preference may prove to be another user's nightmare. It has been interesting to observe the enthusiasm with which batch processing capabilities have been received in a marketplace flooded with user-friendly, interactive software. It is hard to avoid concluding that one of the reasons for this is that, in time, users tire of answering the same questions over and over again to accomplish simple tasks and are relieved when these commands can be submitted to the computer in a batch, leaving the computer to operate unattended and saving valuable user time. Surely the question of what is user-friendly is much more complex than the various advocates of menu-driven operation or non-procedural, "English-like" command languages would like us to believe.

Given the enormous potential of these new systems, especially those with large memories and storage capacities, truly revolutionary approaches to software design are needed, and it seems that we must wait for the visionaries who will propose them. In the interim, intelligent attempts to define the ergonomics of software, such as that provided by Louis Fried at SRI International, will have to suffice;(39) and users will simply have to work within a marketplace where quick development is critical and familiar approaches to computing are called upon to speed product implementation.

Despite the claims of software advertisements, use of even the most user-friendly software may require a considerable amount of training, reading, and experimentation, particularly for those unfamiliar with computers. Sources of instruction may be limited as well. While documentation has improved, particularly for software that has survived several years in the marketplace, it is still often poorly organized, poorly written, and incomplete. Users not thoroughly steeped in the jargon and lore of microcomputing are likely to find instruction manuals difficult reading.

### 4.2.1 Operating Systems

The operating system of a microcomputer is a collection of computer programs, generally written in a microprocessor specific assembly language, that enables the computer to perform basic system operations, such as printing characters on a video display console or managing files on a floppy disk. The operating system also provides an environment in which general purpose application programs can be developed and run.

Microcomputer operating systems may be roughly categorized as single-user and multiuser systems. Within each of these two categories, they may be further divided into single-task or multitasking operating systems. The simplest (and the most common) microcomputer operating systems are single-user, single-task systems. These systems will allow one user to perform one task at a time. If the single-user system supports multiple tasks, the user may begin additional tasks before the first is finished, allowing the tasks to compete for or share available resources until their work is done. A very simple example of a multitasking operating system is one which allows the computer to print the contents of a file while other processing work such as data entry is being carried out. Multiuser operating systems will allow a single system to support several active user terminals. These operating systems may be either single- or multitasking; generally they will have multitasking capability.

Microcomputer operating systems are in most cases designed for a particular microprocessor chip. CP/M, for example, was designed for the Intel 8080 microprocessor, and it is not commonly found on systems using chips other than those of the Intel 8080 series (or the Żilog Z80, a chip that adopted the entire Intel 8080 instruction set). The effect of this situation is that microcomputer operating systems tend not to be particularly portable, i.e., the same operating system is not likely to be found on different systems employing different microprocessor chips. There are exceptions to this rule, however. The UNIX operating system is written for the most part in a high level language, C, and contains only small segments of code that must be closely tailored to the instruction set of a given microprocessor. Similarly, the UCSD p-System consists primarily of so-called p-code instructions that can, in turn, be translated into microprocessor instructions once a p-code interpreter has been developed for the system. The effect of this is that UNIX and the UCSD p-System are

considered relatively "portable" operating systems. This portability means that there will be a better than average chance that the operating system will be available for several quite different microcomputer systems.

Even when microcomputer systems are based upon the same microprocessor chip, an operating system designed for one microcomputer system must be modified to accommodate other configurations. For example, if Company X puts together a Z80 based microcomputer system and decides that it would like to use the CP/M operating system, Company X will purchase a license from Digital Research for CP/M and then make the necessary changes to the operating system (or pay to have them made) to adapt it to the particular configuration the company has chosen. In buying a system from Company X, the buyer would also purchase the CP/M operating system in its modified form directly from Company X. If the user were later to decide to modify the system bought from Company X, adding for example a Winchester disk, changes to the operating system would be required. These changes, since they are often technically difficult, are usually purchased from the vendor as well; but they may on occasion be purchased from the vendor of the peripheral equipment. The ease with which an operating system can be reconfigured to accept different peripherals or different combinations of component parts in systems based on the same microprocessor is another critical factor in the portability of an operating system.

The earlier operating systems available for microcomputers were relatively small and simple systems, in part because they were designed to work in computers with very little memory. Only the most critical programs were designed to be "resident" in memory when the computer was operating; other programs were stored on disk to be called into memory when they were needed. Newer operating systems, having more memory to work in, have tended to become larger and to require more space for resident code.

Operating system design shortcomings can have enormous impact on the performance of a microcomputer system. The operating system may impose unacceptable restrictions on the size of disk files. If the procedures for compiling, assembling, linking and loading are poorly integrated, program development can be more difficult than it need be. Utilities for performing diagnostic tests, editing, sorting, disk maintenance or maintaining libraries of programs may be poor or lacking altogether. The overall performance of a microcomputer system depends to a large extent on the performance of the operating system in handling such things as inputs and outputs.

Current microcomputer operating systems are in some ways considerably less sophisticated than state-of-the-art mainframe operating systems. They do not yet, for example, support virtual memory. This lack of sophistication, however, is not an insurmountable obstacle (after all, much productive work was done on IBM 1401's with relatively primitive operating systems), but it does mean that in complex computer applications a greater burden

may fall on the programmer and user since the system software may not be able to handle the more difficult problems of job and file managment.

EDN's annual microcomputer operating system directory catalogs 80 listings in 1982.(40) A number of these systems are very widely used, perhaps even more widely used than the operating systems that will be briefly treated below, but are specific to the product of a single vendor. Apple DOS, for example, is used by most Apple II users, but DOS has not been used by other system manufacturers (except for manufacturers of Apple II "look-alike" systems) as an operating system for their products. Other operating systems, such as the p-System from the University of California at San Diego (UCSD), are available on numerous microcomputer systems, even systems based on different microprocessor chips. Because these operating systems offer the promise of at least a limited conformity of operation and operating environment across the computer products of many vendors, they deserve some individual attention.

#### 4.2.1.1 Digital Research's CP/M Operating System

The CP/M (Control Program for Microcomputers) operating system, a single-user, single-task operating system for the Intel 8080 and Zilog Z80, was developed in 1975 by Gary Kildall. To the user, it bears a resemblance to Digital Equipment Company's RT-11 operating system. Kildall describes CP/M as "a relatively simple and straightforward operating system, providing the essential functions needed to control physical devices and to support a complete disk file system, but without a lot of 'frills'".(41) CP/M has been enormously successful and has come to dominate the 8-bit operating system market. In mid-1982, more than 400 companies were offering CP/M systems or CP/M related software.(42)

CP/M achieved its strong market position as a result of its early entry in the field, its compactness, its low cost, the ease with which the system can be modified to accommodate different system configurations and the quantity and quality of the documentation and public domain software that has developed for the operating system. The sheer number of software packages available for the CP/M operating system is in itself a testimony to the adequacy of the system's support for program development. Some of its more notable weaknesses include its poor error recovery capabilit , the lack of support for indexed and keyed access to data files, inefficient disk storage, the absence of aids to help the uninitiated user and the lack of linkage software. The simplicity of the system also contributes to annoying omissions such as the lack of a date stamp on disk files. Programs available in both the public and private domain address some of these weaknesses but not all.

CP/M designers planned the move from 8-bit to 16-bit microcomputers carefully and decided that the newer 16-bit operating system would share a common disk format with its 8-bit predecessor. The most

important consequence of this decision is that files created under CP/M can be read by CP/M-86, the version of CP/M designed for the Intel 8088 and 8086 microprocessors. System designers have capitalized on this feature by placing both 8-bit and a 16-bit chips in a system and allowing execution of programs designed for either CP/M or CP/M-86.

In addition to this bridge from 8-bit to 16-bit microcomputers, Digital Research provides multitasking and multiuser versions of the operating system. Concurrent CP/M-86 allows a single user with a single console to operate several "virtual" consoles and, in so doing, to initiate several tasks that can be performed concurrently by the computer. MP/M and MP/M-86 support multiple users and provide print spooling capability, a feature that is not included in CP/M.

#### 4.2.1.2 The UCSD p-System

SofTech Microsystems holds an exclusive licensing arrangement with the University of California at San Diego to maintain and market the UCSD p-System, a single-user, multitasking operating system. The p-System is designed for portability and it is, as a consequence, available for a large number of systems representing a range of microprocessor chips from the MOS Technology 6502 to the Motorola 68000. The operating system itself is written in the high-level language Pascal that is in turn compiled to an intermediate code called p-code. The implementation of the system for a given microcomputer thus requires software capable of executing p-code. Installing the p-System on a microcomputer for which this software is not available requires several months of time and a detailed knowledge of the internal organization of the operating system.(43) Nevertheless, this adaptation generally takes less effort than that of adapting operating systems written in microprocessor specific instructions and the p-System is considered a highly portable operating system.

The p-System offers a well-integrated program development environment and a menu-driven format in which a prompt listing the options available to the user is almost always present at the top of the terminal screen. All compilers for the p-System generate the intermediate p-code instead of native machine code. The advantage of this is that the p-code is concise and requires less disk and memory space than native code but the p-code must rely upon a run-time support system and, while perhaps 10 times faster than interpreted BASIC, is slower in execution than native code. In 1982, the p-System supported only UCSD Pascal, assembler, FORTRAN-77 and BASIC.(44)

#### 4.2.1.3 Phase One's OASIS

The multiuser OASIS system was designed for the Zilog Z80 microprocessor chip and is available for a number of Z80 systems. At the start of 1982, there were more than 20,000 copies of the system in use.(45) OASIS is designed to appeal to the business community and incorporates a number of features not generally

included in microprocessor operating systems. Among these are a file control system supporting four different types of file access, several layers of access and file protection for system and data security, and system diagnostic software.

The 16-bit version of OASIS, OASIS-16, has been written in the high-level language C and has been successfully implemented on Intel 8086-based microcomputer systems. Both versions of the operating system are said to be "friendly", meaning that the operating system does not require a sophisticated user for full utilization.

#### 4.2.1.4 Microsoft's MS-DOS

MS-DOS is a single-user operating system that made its debut in the microcomputer world on a California Computer Products Intel 8088-based system and secured its place in the 16-bit marketplace by appearing on the IBM Personal Computer as PC-DOS. By mid-1982 MS-DOS was expected to be sold with 50 different microcomputer systems.(46) MS-DOS is basically a CP/M-80 derivative. Nevertheless, the literature has been host to an extended debate over the relative advantages of MS-DOS to CP/M-86 for both the user and the software developer. Many of CP/M's rougher edges have been smoothed in MS-DOS; in particular, MS-DOS is said to be friendlier,(47) and it is more efficient in its use of disk space, faster in performing basic input and output routines, and has improved error recovery capability.(48) On the other hand, MS-DOS is considerably more difficult to reconfigure when modifications are made to a system and may require the aid of a skilled assembly-language programmer.(49) MS-DOS also lacks the floppy disk standard that is available with single-sided single-density 8" floppy disks under CP/M-86.(50)

#### 4.2.1.5 Western Electric's UNIX

Ken Thompson of Bell Telephone Laboratories designed and coded the earliest versions of the multiuser operating system UNIX for Digital Equipment Corporation's PDP minicomputer in the late 1960's. Since that time UNIX has been significantly enhanced and modified, and in 1973 it was rewritten in the high-level language C to increase its portability.(51) During the 1970's UNIX was given to many universities and non-profit organizations and became widely used in academic and research settings as the quality and power of the system became well known.(52) UNIX has been installed on mainframes, minicomputers, and microcomputers. There are versions for the IBM 370 as well as the Onyx 8002 (a Zilog Z8000-based microcomputer system).(53)

Having been written by computer programmers for computer programmers, UNIX is remarkably powerful and comes with an impressive collection of programming tools. Unfortunately, many consider it to be difficult to use and "unfriendly" to users.(54) UNIX Version 7 was released by Western Electric in 1979; UNIX System III followed in 1981. A major microcomputer software house, Microsoft, purchased a license for Version 7 and

has developed XENIX, a UNIX system that seeks to address the needs of commercial users.(55)

### 4.2.2 High-Level Languages

The coding of instructions for a microprocessor in the development of software for a particular application can take place at a number of levels. It is possible, though it is rarely done, to generate computer instructions by creating the one's and zero's patterns that correspond to appropriate microprocessor commands. At the next highest level, an assembly language may be used that enables the programmer to write instructions to the microprocessor in a more readable form but still at the level of one assembler statement for every microprocessor command. Assembly language instructions have the great disadvantage that they are microprocessor specific and cannot generally be used on another microprocessor to cause the computer to perform the same task. Macro languages which enable the programmer to issue a set pattern of assembler commands with the use of a single macro statement comprise the next highest level. Although moving towards machine independence, macro languages are still tied closely to the command set of a given microprocessor. At the next level, the high-level language, instructions are language specific rather than machine specific. Programs written in the high-level language FORTRAN, for example, may often be carried from one computer to the next and, with the aid of a FORTRAN compiler, may be used to create the instructions necessary to cause each of the computers to perform the same task.

The development of high-level languages for mainframes opened the door to widespread software development efforts. Programs developed on one system could be transported, sometimes without modification, for use on another computer using a completely different CPU instruction set and operating system. In order to promote this portability of programs, standards were developed for the more important languages by national and international organizations. The availability of a standard and widespread industry adherance to that standard are critical if a language is to be truly portable.

The use of a high-level language may involve the use of an interpreter, in which language statements are examined sequentially with each statement causing a number of machine commands to be issued, or a compiler, in which language statements are translated into a complete collection of machine instructions that may be run without further assistance from a language support program, or some combination of these two approaches. Many microcomputer COBOL language processors are called compilers by their vendors although they merely compile the COBOL statements to an intermediate code that must have the support of a resident run-time interpreter, i.e., a program in memory that can translate the intermediate code into actual machine instructions. Interpreters offer the advantage that they allow easy corrections of programmer coding errors, since editing and execution of the program are performed almost concurrently. Compilers, on the other hand, require that distinct

steps be followed; the editor must be abandoned before the compiler is called and errors in the code are found. Compiled code has the advantage that it is generally more efficient and, consequently, faster in execution.

4.2.2.1 BASIC (Beginners All-Purpose Symbolic Instruction Code)

BASIC is a language developed in the 1960's by John G. Kemeny and Thomas E. Kurtz at Dartmouth University. It is the predominant language for microcomputers today. BASIC interpreters are available as standard equipment on most microcomputer systems sold. The language was developed to "make life easier for the nonexpert programmer,"(56) and broad based support and widespread use are testimony to the success of the language's developers in achieving their goal. BASIC is easy to learn and easy to use, especially for small applications programs.

In its most common form, BASIC is interpreted rather than compiled and it is consequently one of the poorest performers when languages are tested for speed of execution. As use of the language grew and its speed became a common complaint, software developers provided compilers that generate machine code from BASIC instructions and allow the language to be much more competitive in time trials.(57)

BASIC suffers from the lack of an official or unofficial standard. As Kurtz explains it, "what started out as a simple language with no more than a dozen different statements dealing with numbers has grown into a diverse language with many statements capable of handling numbers, strings, arrays, files and plotting. ...Each vendor has developed its own formats and rules for these extensions so that present versions of BASIC differ widely as to form and content."(58) The effect of this situation is that BASIC programs tend not to be very portable if they are required to move from one vendor's interpreter to another.

Help for BASIC may be on the way. A standard is being developed jointly by the ANSI (their proposed standard X3J2) and the European Computer Manufacturers Association (their proposed standard TC21). The committee responsible for preparation of the proposed standard has met since 1974 and is expected to present its proposal to ANSI in 1983.(59) If a standard is adopted and is widely accepted by the software industry, BASIC will be an even stronger competitor among the high-level languages available for microcomputers.

Every language has its defenders and detractors. BASIC is no exception. Seymour Papert, the author of the language LOGO and a professor at MIT, has sharply criticized the language saying that training a person in BASIC provides a tool that will quickly be outgrown and will have ingrained an approach to programming that will frustrate further growth. Even if Papert is right, swimming against the stream of BASIC will not be easy.(60)

#### 4.2.2.2 Pascal

Pascal, too, is one of the newer computer languages and, like BASIC, it has benefitted from its widespread use for computer language training in universities. Developed in the 1960's by Professor Niklaus Wirth, Pascal is a structured language that employs strict "typing" of variables to improve error detection during compilation. Because it is usually compiled and because its syntax is more demanding than that of BASIC, the untrained user may find it more difficult to use.

Attempts to standardize Pascal have resulted in more than one standard.(61) Wirth and Jensen published a user manual and report in 1974 that has been used as a standard by some compiler developers. The International Standards Organization (ISO) worked from 1977 to 1980 on the draft of a standard (ISO/DP 7185) for the language and made a formal proposal in 1980. The ISO proposal is effectively an extension of Wirth's Pascal. UCSD Pascal is so widely used that it, too, has become a standard in its own right. The existence of three strong standards that are not in agreement undercuts the advantage of a standard, which is its ability to encourage uniformity in the many implementations of the language.(62)

There are deficiencies of the language as it is defined by the standards that may inhibit its wide acceptance as well. Pascal is criticized for its weakness in handling input and output (especially in its failure to support random access) and strings and for its lack of support for dynamic arrays.(63) In some cases, the nicer features of a particular implementation of the language, such as the ability to compile subroutines separately and to form libraries of subroutines, prove to be extensions of the Pascal standards.

#### 4.2.2.3 FORTRAN (FORmula TRANslator)

Developed in 1957 by IBM, FORTRAN is one of the oldest of the high-level languages available for microcomputers. The language has been widely used by mainframe computer software developers and official standards for it have been developed by both the ANSI and the ISO. The earliest ANSI standard, published in 1966, described two levels of the language, basic FORTRAN and full FORTRAN. As pressures for development of the language continued after the first standards appeared, the ANSI produced a revised standard in 1977 that added several features to the ANSI-66 standard. Microcomputer implementations of FORTRAN include packages meeting both the 1966 and the 1977 standards; most, though not all, are compilers producing native microprocessor code.

In addition to a well-established standard, FORTRAN offers a powerful instruction set, support for large integer values and the ability to call externally compiled procedures. The language unfortunately offers few other facilities for structured programming. Its popularity on microcomputers has begun to slip and, in a survey of users taken in 1982, FORTRAN has dropped to

third place (behind BASIC and Pascal) in the number of operating systems offering support for the language.(64)

#### 4.2.2.4 COBOL (COmmon Business Oriented Language)

One of the most widely used languages on mainframe computers, COBOL, has been slow in winning acceptance among microcomputer users. The language places considerable demands on microcomputer resources, and, in the earliest days of small systems. these demands were simply unreasonable. Implementations of COBOL for 8-bit microcomputers have provided a fairly full ANSI standard, but they have also required run-time interpreters resident in memory to support execution of the compiled code, further limiting the size of programs that could be generated.

As the memory and disk storage resources available on microcomputers increase, COBOL may become a serious contender among the languages available for these systems, capitalizing upon the availablity of COBOL programming skills and existing software and the more powerful features of the language. Seasoned microcomputer users continue, nevertheless, to warn against the use of COBOL on small systems,(65) but COBOL will probably continue to find strong support from the business community.

#### 4.2.2.5 C

The language C was designed by Dennis Ritchie at Bell Telephone Laboratories in the 1970's and was first implemented under UNIX on a DEC PDP-11. Ritchie and his colleague Brian W. Kernighan call C a relatively "low-level" language because it "deals with the same sort of objects that most computers do, namely characters, numbers and addresses."(66) Even input/output operations are not a part of the language; they are supported instead by explicitly called functions. C is a sophisticated language that gives the user almost assembly language control over the computer. It suffers from the lack of an established standard and from the fact that its code is relatively difficult to master and to read.

Interest in C is increasing among microcomputer users, and its position is likely be further strengthened if UNIX is widely adopted by 16-bit microcomputer users.

#### 4.2.2.6 Other High-Level Languages

PL/I (Programming Language, Version 1), first introduced in 1960 by IBM for its 360 series, is also available for microcomputers. Digital Research has develooed a PL/I compiler for both CP/M and CP/M-86 that has been favorably reviewed in the literature.(67) The compiler has performed well in benchmark tests, placing fourth in speed among the languages tested on Z80 based systems.(68)

Ada, a new programming language whose development was funded by the U.S. Department of Defense (DOD), may become a strong contender for language popularity in time. While complete compilers for the language are available,(69) most are only subsets of the language

and there is some question whether these subsets will be able to use the name Ada since the DOD is said to be determined to see that the standard for Ada be strictly followed.(70)

LISP, the language of artificial intelligence, has attracted some attention among microcomputer users,(71) though it is not likely to gain wide acceptance. APL (Advanced Programming Language), perhaps the most sophisticated of programming languages, is also available from several different sources.(72) Other languages including LOGO, PILOT, and FORTH are available but seem unlikely to be of general interest for statistical computing.

### 4.2.3 Application Software

#### 4.2.3.1 Data Base Management Software

Offerings of so-called data-base management software in the microcomputer marketplace are sufficiently numerous and varied in their data handling capabilities that authors reviewing this software generally accede to the vendor's classification of the software and avoid any attempts to further classify or reject packages that fail to offer a predetermined complement of tools for dealing with data. As an editor of a major industry journal has put it, "In the face of emphatic but often contradictory definitions from industry experts, [we have] fallen back on a general definition combining those of many microcomputer database vendors: a data base manager is a program or set of programs that allows a user to organize, maintain, and query data files and to generate custom-designed reports from them."(73) Once so broad a definition is accepted, it is exceptionally difficult to compare the large number of products available in a manner that is both complete and concise enough to be useful.

The range of sophistication and power of microcomputer database software is considerable. Sophistication refers to the complexity of the databases that may be described and managed. Power refers generally to the size of the databases that may be worked with and the complexity of the operations that system commands may prompt. On the one hand, early database packages like DBMaster for the Apple II were limited in power and sophistication and were so awkward to use that all but the simplest tasks required considerable effort. On the other hand, MDBS, one of the very few complete implementations of a database system meeting CODASYL (Conference on Data System Languages) specifications, is available for microcomputers. MDBS is perhaps one of the most sophisticated and powerful database management packages available for any computer system. It also tends to be relatively difficult to use, not because of poor design, but because the sophistication of the software requires considerable training and knowledge on the part of the user.

There are, fortunately, a large number of database management packages for microcomputers that fall somewhere between these two ends of the spectrum. The cost of database software is generally higher than the cost of any other microcomputer application

software, with the exception perhaps of operating system software, and ranges from approximately $250 to well over $1,000. Despite this, database software is one of the largest and fastest growing segments of the software industry.

The capabilities of many of these packages are impressive. Some are able to deal with multiple databases concurrently. Some support file structures that allow database files to be accessed by other system software. Limits on the number of records per file or the number of fields per record or the length of a field differ considerably from package to package. Some are menu-driven (for example, Condor); others employ an extensive command language (dBASE II, for example). Password security controlling access to data files or selected fields of data files has been implemented in only a few database systems and security features as a whole appear to be one area of general weakness.(74)

4.2.3.2 Statistical Software

Any examination of the literature will verify that statistical packages for microcomputers, too, are abundant. These packages differ not only in the number of statistical functions that they provide but in the power of their data handling features as well. Until late 1982 there was nothing available for microcomputers that began to approach the data handling capabilities or the statistical power of mainframe statistical software, such as SPSS, SAS, P-Stat or BMDP. With the introduction of Motorola 68000-based microcomputers, BMDP became the first of these major mainframe statistical software vendors to release an integrated microcomputer system supporting its software package with the BMDP Stat Cat.

Excluding these very recent market entries, statistical software for microcomputers is modest when compared to standard mainframe computer software. Although they vary considerably in the way their features are integrated, many statistical packages support the user from data entry through data analysis to completed tables or results. Unfortunately, the best integrated packages tend to be the most resistant to accommodating data in different formats. Some packages may be unable to work with data in formats other than that supported by their own data entry routines. The ability to specify the format of the data contained in a file that is to be studied, such as that provided in an SPSS input data statement, is not a common feature. Any attempt to work with data from sources other than databases created by the statistical package itself involves the use of custom programs to reformat the data to be examined. Few packages offer the user the opportunity to work with flexible data formats.

The data handling capabilities of statistical packages varies from no facility for correcting the value of a variable to a fairly complete set of functions to examine and change values. Statistical packages generally fall short of the flexibility of data base management packages in their data editing capability.

While the microcomputer itself may not limit the size or precision of numbers that may be manipulated by the statistical package, the source language used by system implementers generally does. In the case of the Northwest Analytical (NWA) STATPAK which is coded in Microsoft BASIC, the upper limit placed on integers is 32,767. This is not meant to single out NWA STATPAK; on the contrary, it is mentioned only because its documentation is exceptionally straightforward in dealing with this issue. Such a limitation is severe, even when small files are involved . Of course, there are ways to avoid problems with such a restriction (for example, entering data in units of 1000), but in most cases it would be desirable to have more room in which to maneuver.

The number of software packages designed specifically to produce tabulations is small. One of the reasons for this is that much of the demand for tabulations within the marketplace can be met by the report facilities included in database management software. These capabilities are not generally satisfactory for the generation of tables characteristic of survey reports. The tabulation software that is available is limited in flexibility and the generation of detailed analytical tables, while perhaps possible, is likely to be awkward and time-consuming.

#### 4.2.3.3 Graphics Software

One of the most impressive feature of many microcomputers is their ability to generate graphics displays. Software to help the user capitalize on the graphics capabilities of a system has been somewhat slow in materializing but is becoming increasingly common. Most of these packages support the creation of line graphs, bar charts, and pie charts. Some make it possible to use color in the generation of these graphs. Some support the printing or plotting of graphs that have been created on a video display, while others can accommodate a digitizer or other specialized forms of input. Packages vary considerably in the flexibility that is given to the user for customizing the graphs that are generated. Many are completely menu-driven.

The Apple II user has perhaps a wider selection of graphics packages than any other, including the CP/M user, although the IBM Personal Computer is also developing an impressive array of business graphics packages. Prices for this software vary from just over $100 (PFS Graph for the Apple II costs $125)(75) to about $20,000 for a medium-resolution graphics system that includes a microcomputer with a CP/M-compatible operating system as part of the package (The Beacon from Florida Computer Graphics).(76)

As the speed and memory capacity of microcomputers continue to increase, the resolution and the power of the graphics software available can also be expected to increase. Industry forecasters see business graphics as one of the fastest growing segments of the software industry and are optimistic about the future of microcomputer graphics.

#### 4.2.3.4 Data Entry Software

Small microcomputers are frequently used for data entry, and software developers have responded to the need for software support for this activity with packages designed such as RADAR and Datastar to make data entry a straightforward task not involving programming. Some of these programs allow range and type editing and support the use of check digits.

In addition, there are packages available that support the user in the development of custom programs for screen oriented data entry by leading the user through a series of steps that define the data entry requirements and make it possible for code to be automatically generated. The Last One, Pearl III, and The Screen Handler are all examples of this type of software.

#### 4.2.3.5 Word Processing Software

High demand and an extremely competitive marketplace have led to impressive improvements in the word processing software available for microcomputers. In September 1982, the editors of one industry journal found more than 75 word processing packages to review and, in contrast to their reaction some 12 months earlier, found themselves impressed by the quality of the software available. In addition, most microcomputer word processing packages are priced under $500, making the microcomputer an attractive alternative to more expensive dedicated word processing systems.(77)

Word processing software usually allows for the creation and editing of documents, using the facilities provided by the microcomputer's keyboard and video display. Utility functions are included to allow the user to store, copy, and merge documents or parts of documents, search for and replace strings of characters, and move freely through the document to perform editing tasks. Most packages support formatting functions that assist in the preparation of finished documents. Centering, underlining, left- and right-justification, and automatic page numbering are all common features. In some cases the software is able to make use of the special features of the printer attached to the system, allowing for changes in pitch, subscripts, superscripts, overprinting, and shadowing.

In addition to word processing facilities, many packages offer extensions that provide routines for the support of mathematical calculations, graphics, mailing lists, and appointment scheduling. Programs that will check for spelling and grammatical errors are also available. <u>Mini-Micro Systems</u> has designed a two-page check list of word processing software features that could be useful in selecting an appropriate package.(78)

#### 4.2.3.6 Electronic Spreadsheet Software

The enormous popularity of VisiCalc, the first of the electronic spreadsheets available for microcomputers, was one of the primary

reasons for the success of the Apple computer, and spreadsheet software has continued to be a popular item for microcomputer users. Although conceived primarily as a financial modelling package, the electronic spreadsheet has found much broader application due to the flexibility of its support for the manipulation of numerics and text. By allowing the user to specify mathematical relationships between spread sheet variables and to change the value of variables, and by automatically calculating the new values of all dependent variables, electronic spreadsheet software makes the microcomputer a powerful tool for financial work or the creation of specialized tables. In mid-1982, there were more than 24 spreadsheet packages available.(79) Prices range from $50 to $1500 but are most commonly set between $250 and $500.(80)

#### 4.2.3.7 Communications Software

Specialized software is required to support communication between a microcomputer and another computer via a modem. Packaged software for this purpose is usually designed for use with a particular operating system and, often, a particular brand of modem. There are packages that will allow a microcomputer to emulate a mainframe terminal (for example, MICRO-SNA/3270 provides the necessary software support to make a CP/M-86 based system emulate the operation of an IBM 3274, 3276, 3278 or 328X remote terminal) and others that provide more flexible and general purpose protocols to facilitate communications between a variety of systems (P-TERM allows Apple Pascal users to transfer ASCII files under a variety of protocols at rates up to 1200 baud). Packages designed for use with modems offering automatic dail-up or answer-back facilities provide the support necessary to make use of these features.

Attempts to install and use packaged communication software that is not, at time of purchase, tailored to the particular configuration with which it is to be used may be trying. Modification of this software, even when the producer has made provision for it, is likely to require a high level of understanding of the software and hardware involved. Unless the documentation of both is excellent, successful installation of the package may be impossible.

#### 4.2.3.8 General Utilities

##### 4.2.3.8.1 Text Editors

The text editor is one of the most fundamental of software packages. Ordinarily it will be included with operating system software, though the operating system editor may be inadequate or inconvenient for regular use. Text editors can be divided roughly into two different types, (1) line-oriented and command driven or (2) full-screen editors. Both types of editors have their strengths, though in program development the full-screen editor is preferable. Some packages incorporate both approaches. Word processing software that allows editing of files without automatic justification or pagination will often prove an acceptable or desirable alternative to the text editor.

4.2.3.8.2 File Conversion Software

Occasionally, software is available that will make the changes necessary to convert disk files written in differing formats. The success of this software is dependent upon the compatibility of the disk drives used; software cannot account for some of the differences that occur from one floppy disk drive to another (such as recording density). File conversion software is of particular use when more than one operating system with incompatible disk formats is used on the same microcomputer system.

4.2.3.8.3 Diagnostic Programs

Diagnostic software that will perform routine tests of the major components of the microcomputer such as memory, CPU, disk drives, terminal, and printer can be of use in isolating the cause of puzzling failures and recurrent problems. The more general purpose packages available require that the system be in good operating condition to be of use and are of no practical value once the system has failed.

4.2.3.8.4 Disk Maintenance Software

Packages that offer the user a window on disk storage and permit access to those parts of the disk used exclusively by the operating system may be of use in recovering files that have been accidentally erased or in saving parts of files that have been accidentally corrupted. Disk maintenance software is available at prices under $100.

4.2.3.8.5 Sort/Merge Programs

One of the more common activities when working with sequential files is that of sorting and merging. Mainframe computers have traditionally had packages that allowed considerable flexibility in performing this task, and similar software has been developed for microcomputers as well. It is helpful if the sort utility provides some reformatting capability for use in converting files written by one high-level language to files that can be read by another. For example, the utility SuperSort allows the user to convert BASIC data files into files that can be read by a FORTRAN program.

4.2.4 Mechanism for Supply

While mainframe software has traditionally been purchased from major system vendors (in the case of operating systems and compilers) or from large software houses (in the case of application software such as data base management systems), sources of microcomputer software are comparatively modest and much more numerous. The microcomputer software industry is something of a home industry; and, although there are notable exceptions, much software development is accomplished by individuals or small groups of individuals rather than large companies.

Microcomputer software may be available from the author of the software (as is the case with SL-Micro), from a software house that has produced the package (as is the case with MBASIC), rom a software publisher (such as Lifeboat Associates) that has worked with an author to bring the software up to the publisher's standard, or from a software distributor (such as Softsel Computer Products) that reviews published software and provides services for the customer that are seldom available from publishers. The software publisher offers the author the advantages of a name known in the marketplace and may offer the support necessary to release the software in a number of disk formats. Demand for customer support appears to be encouraging the growth of software distributors that have technical experts select software from many publishers that they in turn will stock and sell.

Software is distributed on floppy disks. The large number of differing formats and disk drives in use make distribution more of a problem than it might be. Software publishers and distributors are more likely to have software available for equipment from major vendors such as Apple, TRS-80, IBM-PC, or for a popular operating system, such as CP/M (8-inch single-sided, single-density) than they are for equipment employing less common formats. Owners of systems with unusual disk drives or of drives employing unusual disk formats may be forced to rely on the system vendor for all software unless some other means of transfer can be found.

Normally source code is not available and only object code may be purchased. The effect of this is that there is little chance for custom alteration of packaged software, and the user must be satisfied to work with the capabilities of the package as purchased. The buyer makes a one-time purchase and receives a particular version of the package (bugs and all). Subsequent updates to that version or new versions of the package are, in most cases, an additional purchase. Some software houses sell a maintenance contract that may provide for automatic upgrades of the software at no additional cost. Occasionally, software vendors offer new versions or new releases to the owners of earlier versions at reduced cost, with the return of the old software.

Purchase of software usually involves a signed agreement between the software author or publisher and the buyer in which the buyer agrees to abide by certain restrictions on use and/or copying imposed by the holder of copyright. Software piracy (the illegal copying of copyright material) is an enormous industry problem that has received a wide range of response. Publishers of the more popular packages have tended to rely upon the cooperation and good faith of computer users and have made it easy to create backup and working copies of the master disk(s). Other vendors have gone to extraordinary lengths to discourage illegal copying and severely restrict the user by including code that inhibits attempts to copy the master disk(s).

Software purchase agreements, when they allow copies of the software to be made, often limit the number of those copies or specify that the software is to be used on one system only.

Purchasers should be aware that they may be legally required to purchase a dozen copies of a particular package if they wish to use it on a dozen systems. Although microcomputer software packages are considerably cheaper than mainframe packages, the overall cost of software in a distributed system may not be substantially less in the long run.

## 4.3 Mode of Operation

The majority of microcomputers today are stand-alone machines with single users and no reliance on other computers. However, the multiuser microcomputer market is opening up, offering timesharing, multiprocessing, and distributed processing. In addition, communications with external equipment may be achieved in any one of these environments by use of software and a direct connection or a modem and telephone lines. The mode of operation is largely a function of the task to be accomplished and may not always be the same for any particular system.

### 4.3.1 Communications

Since communications capability spans both the single-user and multiuser environments, it will be addressed first. Incompatibilities in format among magnetic media, such as floppy disks, have made it very difficult to share programs or data with anyone using a different microcomputer without communications capability. The power of a microcomputer is greatly enhanced when it can communicate with geographically distant computers. Computers can attain increased efficiency by sharing both resources and data, or by distributing the work load among connected computers. These capabilities also increase the versatility of the computer as a tool, and make possible such services as electronic mail and quick access to data.(81)

If the microcomputer is to be used as a terminal into a larger system, communication is made possible by using a serial port and either a direct wire connection or a modem at each end. A modem is a device which converts digital signals to sound and vice versa. Most modems communicate at 300 baud, or about 30 characters per second and cost approximately $180. At a higher cost, it is possible to obtain 1200 baud communications over phone lines. If the distance to be bridged is several hundred feet or less, the modem is not needed and a direct wire connection may be used instead, with perhaps as much as a 19,200 baud rate.(82)

In any case, communications software must be written or purchased to control the communication. This is not trivial software, especially in an interrupt-driven system. There are many such packages on the market, among them ASCOM and PTERM.

Two special modem features may be of value in certain applications. One is automatic answerback, which would allow a user elsewhere to dial into the microcomputer with the modem. Bulletin board and message exchange systems have been created by setting up a microcomputer into which people may dial in this fashion. Another

feature is automatic outbound dialing, in which the computer passes the phone number to the modem and it generates the appropriate touch-tone frequencies. This may be used for such things as unattended late-evening communication with other computers.(83)

Communications is a key part of establishing the sharing of resources through networking, which will be discussed under distributed processing.

Roughly one third of the microcomputer users queried through a survey questionniare developed for the study had achieved communications of some sort and many others expressed the desire to do so. Among those were users in Kenya, Chile, and Fiji. In addition, some of the users surveyed reported successful exchange of information, programs, or data via floppy disk or cassette tape, in lieu of communications capability. These included the following:

-- Users in Sierra Leone who sent North Star diskettes through the mail;
-- Users in Mauritania who created Altos 8" floppy disks to be read by an IBM mainframe;
-- Users in Indonesia; and
-- Users in West Africa who created TRS cassettes to be read by a CDC 6500 mainframe.

### 4.3.2 Single-user Systems

Many of the more popular systems in use today are single-user systems, such as the Apple II and the IBM Personal Computer. This is intentional on the part of the vendor and is not to say that such machines are lacking in power. Their power is simply directed to one user. A typical computer system consists of a central processing unit (CPU) with perhaps 64KB of random-access memory (RAM), a keyboard for input, a display such as a video monitor, a printer or terminal for hard-copy output including graphics, one or two floppy disk drives for storing programs and data, and one or more high-level programming languages such as Pascal or FORTRAN.

### 4.3.3 Multiuser Systems

The multiuser microcomputer is relatively new. Today general purpose multiuser systems are offered by: Ace Computers, Alpha Micro, Altos, CCS, CompuPro, Cromenco, Convergent Technologies, CORVUS, Dynabyte, Integrated Business Computers, Intertec, Morrow Designs, North Star, Onyx, OSM, Zobex, and a host of others.(84) Three distinct organizations are used to support multiple users: timesharing, multiprocessing, and distributed processing.

#### 4.3.3.1 Timesharing

Timesharing is the same as that used by mainframe timesharing systems. One CPU is shared among all users. Each user has a separate address space which may or may not be permanently tied to a particular area of real memory. Users share a common file system

and peripherals. Usually, disk storage accesses proceed asynchronously from CPU activity so that the file activity of one user does not block other users who are not accessing files. The chief bottlenecks in this kind of system are the file system and the CPU.(85)

The timesharing approach is probably the simplest to develop; it involves a minimal amount of hardware development and probably not as much software development as the alternatives. It has the lowest hardware cost as well. For a very small number of light users, timesharing-type microsystems may be appropriate. The Altos ACS8000 series and the Onyx C8001 are Z80-based timesharing systems with hard disks. When lightly loaded with a couple of users, response is good. With three or more users, response degrades quickly.(86)

The user survey showed that approximately one-sixth of those queried were employing timesharing. Most of them responded that system degradation was largely a function of the mix of programs running at any one time. An Onyx 8001 user commented that his system could handle up to three users with no problem. North Star users in Jamaica and Sierra Leone noted serious system degradation with two or more users.

4.3.3.2 <u>Multiprocessing</u>

Multiprocessing implies an organization where each user has a dedicated CPU, which currently is often a Z80. To limit memory contention, each dedicated CPU has its own memory that is completely available for user application programs or systems. All users share a single file system which is managed by a special system processor. When a processor needs file access, it invokes the system processor to perform the I/O. The user terminals are handled by the system processor which supports miscellaneous non-file tasks as well.(87)

4.3.3.3 <u>Distributed Processing</u>

The distributed, or local area network, approach links independent systems together to share a common file system, printers, and any other scarce resources. Each user has a workstation which is a complete system with its own disk storage. The common file system is used primarily for interuser file transfer. The workstations and the common server are attached via communication facilities which may be quite simple or very elaborate. Workstations can be attached or detached without affecting the system's ability to function. Good distributed systems should operate with few bottlenecks.(88)

Communications is an integral component to networking. When distances of a few hundred feet or less are involved, it is possible to obtain quite high communication speeds, an especially useful characteristic for sharing access to a large, relatively costly hard disk and associated backup device. The Convergent Technologies system uses such a network. The CORVUS Company offers

a network as an add-on to many of the more popular microcomputers. Xerox has made it possible to attach its microcomputer to what they call Ethernet, which promises high performance.(89) In the micro world, the CORVUS Omninet is the leader; it is relatively cheap and can communicate with much more elaborate systems such as Ethernet through a gateway.(90) The main reasons for the growing interest in local networking are plummeting costs of microcomputer power and increasing recognition of the benefits of multiuser systems. Users of the HiNet network, for example, can link up to 30 Z80-based workstations -- each with 64K bytes of memory and costing only $2,000 each -- for a variety of business and industrial applications.(91)

Network access offers exciting possibilities in the area of computer-assisted conferencing as well as data base maintenance. Experiments are being conducted at the University of Hawaii using the Electronic Information Exchange System to permit electronic conferences to be conducted with any PLATO user, citizens of any of the 15 nations and jurisdictions served by the PEACESTAT satellite system, and any individual within local phone range of Honolulu. Compared to the high cost of either face to face or phone conversations over comparable physical distances, interactive network communication offers valuable alternatives for the timely exchange of information.(92)

A standards battle is brewing as networking grows in popularity. It is desirable that users of Ethernet be able to pass information to users of HiNet using a common format. Today no such format has been universally accepted. Applications software may be the only way to bridge the incompatibility.

New developments seem to be taking microcomputing into the complexities that have grown up with mainframe computing and away from the simplicity that was once the hallmark of this technology. E.B. James, of Imperial College in London, has a negative attitude toward networking: "Microelectronics provides personal, interactive computer power for the first time and is valuable <u>because</u> the user is free of restrictions from: computer centers, computer managers, network controllers, timesharing systems, large operating systems, systems programmers, network protocols, and systems that change every day."(93)

The point remains that the mode of operation must be appropriate to the task to be performed. Just as the lone researcher doesn't need the power of a 30-workstation network, the data entry manager requires more entry facility than that provided by a single-user system.

Examples of distributed processing are beginning to come from other areas outside the U.S. and other highly developed countries. An agriculture project in Nairobi, Kenya, is using two Digital Micro Systems microcomputers linked by HiNet.(94) The U.S. Bureau of the Census is using CORVUS' Omninet to connect a system of 10 Apple microcomputers and 4 20-MB Winchester disks in order to process the 1983 Economic Census in Puerto Rico.

The reader should note that in the purest sense distributed processing is considered to be a multiuser organization. However, throughout the rest of the report the term "multiuser system" is used to refer to those systems which support multiple users but do not employ a network; the latter are referred to as "networked systems."

## 4.4 Size and Environment

Small size is one of the primary characteristics of microcomputers, as the name would imply. The effect of large scale integration has been to produce powerful computers that fit nicely on a desk. In fact, one of the points of comparison for microcomputers is the "footprint," or quantity of desktop space, required for each machine. If the microcomputer comes in detachable modules, one can leave just the keyboard on the desk. Wang has an elegant solution: its central unit hangs off the side of a desk and an accessory adjustable arm holds the CRT in mid-air, freeing the desktop below.(95)

The fact that microcomputers are much less demanding in terms of the environment in which they can operate has been a big selling point. In years past, obtaining a computer meant creating a room with a false floor for the maze of cables that connected the components and purchasing an air conditioning system with a lot of power. Today's microcomputer will operate reliably within a range of about +50 to +90 degrees F, and with humidity from 20 to 80 percent (non-condensing). If the environment is extremely dirty or dusty an air filter should be provided. Continuous vibration, such as that on a ship, may not be a problem. Sudden shocks, however, may require special mounting of the equipment.(96)

Many operating environments are not as electrically ideal as they need to be. Microcomputer operation depends on a "clean" power line, free of voltage irregularities. As microcomputers become more intricate and operate at higher speeds, they are, in turn, increasingly sensitive to line fluctuations and outside signals.(97) However, there are devices on the market to analyze the power and others to correct it if it is problematic.

Roughly a third of the users surveyed for this study indicated that their microcomputers were subject to excessive dust, moisture, temperature, or a combination of these, and yet were functioning acceptably. One user from Indonesia did report a problem with wet fungus growing on the circuit boards. In this case, air conditioning was necessary. A third of those surveyed expressed problems with electrical supply.

## 4.5 Cost

It is difficult to say whether "micro" refers more to size or cost of microcomputers. Certainly one of the big attractions of these machines is their cost. Discussing hardware cost is like shooting at a moving target because it is constantly decreasing. In addition, microcomputer systems range from self-contained portable

models to elaborate systems with many components. Regardless, it is a fact that the cost of certain operations in computing has come down by a factor of between 100 and 1,000.(98) Rodnay Zaks states, "A typical general-purpose microprocessor today sells for around $10, and can go as low as $1 to $2 if purchased in large quantities."(99)

Of course, as IBM recognized years ago, people buy complete systems, not CPU's. Perhaps Cary Lu, managing editor of High Technology, has stated the situation a little more realistically: "The price of a working microcomputer system runs from about $4,500 to $8,000, but everyone expects fierce competition with a price war in 1983. As memory and peripheral prices decline, a complete minimal system could be sold profitably for less than $3,000 by the end of 1983."(100)

There is a startling differential between the cost of software for microcomputers and that of mainframe or even minicomputers. Says Fidelis M. Umeh of Information Management Technologies, "Take the PL/1-80 compiler, which costs under $500. The PL/1 optimizing compiler, which does essentially the same thing as far as the user is concerned, costs a minimum of $600 per month -- you can't even buy it."(101) The equivalent situation exists with a package called SL-Micro, which costs $195 and permits the microcomputer user to do the more commonly used routines in SPSS, a package for larger computers which requires a yearly $4,000 licensing fee.

E.B. James cautions against looking at hardware or software cost in isolation, but, stresses the <u>overall</u> cost of microcomputing. The cost of people's time must definitely be a factor. He states that the <u>apparent</u> cost of computing is down by a factor of ten over the last 5 years.(102)

For many of the users surveyed, cost was a prime consideration in their decision to use microcomputers. If distributed processing was involved, as was the case in Purdue University's agriculture project in Francophone Africa, microcomputers were the only way to be cost-effective. Despite the low cost of her North Star microcomputer, Beulah Edoo, of the Ministry of Agriculture in Jamaica, states that the cost of storing data on floppy disks is 15 times the cost of using magnetic tape.

## 4.6 <u>Personnel</u>

The claims to user-friendliness that have accompanied the microcomputer have made it seem possible for anyone to sit down and compute without understanding anything about how a computer works. It is fair to say that microcomputers have made it easier for the person without a data processing background to become productive, but at the same time it must be recognized that there are many levels of involvement in microcomputing and this person will not be successful in all of them.

The first level involves integrating a microcomputer system. If the system is not purchased as an "off-the-shelf" item, someone

with a fair degree of knowledge at the board level must put the pieces together. This involves identifying the appropriate cables, setting baud rates, and even making changes to the operating system. An electrical engineering background is a big asset.

Once the system is integrated, software must either be written or purchased. If it is to be written, someone must know BASIC, Pascal, or another language supported by the operating system. (If the language is not included with the operating system, it must first be installed on the microcomputer.) In addition, he will probably need to know how to use a text editor in order to make modifications. He must understand what data formats are supported by the language and how to make the data accessible to the program, if data are involved.

If the software is to be purchased as packages, someone must install them on the microcomputer. Many packages are written to be portable across multiple microcomputers and must be adapted to a particular machine. The documentation is often sketchy, leaving questions in the mind of the person doing the installation.

When software is in place and if it is sufficiently turn-key or menu-driven, then and only then can the novice computer user sit down and be productive. Even then, he must understand what the various components of the machine are, how to properly turn them on and off, how to initiate use of the software, how to respond if error messages occur, and how to care for the equipment.

Beyond the day-to-day use of the machine is the question of who repairs it when one or more components break. This type of repair requires someone who can diagnose the problem and then remedy it. It may be only a matter of swapping a board or it may be something more serious. The person responsible must have at least some training in microcomputer maintenance.

The use to which the microcomputer is to be put and the number of microcomputers involved largely determine the personnel structure needed. If the application is turn-key, for example, a vendor can supply an integrated hardware-software solution. Repair can be handled by contracting with a company which provides maintenance. In this situation, training in data processing and computer experience are not necessary for the microcomputer users. This application would be typical of a billing system for a doctor's office, an accounting system for a small business, or a word processing system for a publishing house.

At the other extreme, consider a large government agency which has decided to put microcomputers in each department for program development and analysis, requiring communication with mainframe computers. Most applications are oriented toward research and development and are customized. In addition, some applications require special capabilities such as graphics. For most departments, off-the-shelf systems will suffice; for the others, a degree of customization is necessary to integrate the components. The agency has a staff of in-house technicians who work on the

mainframe computers. They are qualified to do the system integration of the microcomputers. Communications capability is necessary to link the microcomputers with the mainframe computers. Packaged software is purchased and modified as necessary to achieve communications. A short course in BASIC and Pascal is offered to computer programmers to prepare them to best utilize the microcomputers. The agency's analysts are given training in several statistical packages. A small staff is set up to provide support to the microcomputer users and to do troubleshooting if problems arise. Finally, the decision is made to handle maintenance internally by training persons already doing mainframe maintenance. It is obvious that the staffing requirements in these two situations are quite different.

E. B. James notes that in most cases the people who are pioneering the use of personal microcomputers in research and development are often comparative beginners in general computing. He continues to say that the experienced users of large computing systems have not yet become aware of the possibilities in microcomputing or, even if they are, are not psychologically prepared to change their habits of computer use.(103) His point is that persons with a lot of training and experience do not necessarily make the best microcomputer users, but that the characteristics most needed by personnel connected with microcomputers are a progressive attitude, open-mindedness, and a desire to make the most of this new technology.

The introduction of microcomputers must be accompanied by a training program if they are to be used successfully. On the most comprehensive scale, such a program needs to address the needs of the manager, the microcomputer user, the programmer, and the service technician. Without adequate training of those persons to be involved with the microcomputer or microcomputers, it is quite possible that powerful microcomputer systems will be used ineffectively or not used at all. Business periodicals bear numerous articles depicting disappointments suffered by companies who did not consider proper taining when they purchased their microcomputer systems.

It should be mentioned that the acquisition of microcomputers does not diminish the need for a central support staff. In fact, it may be necessary to identify one person or several people who specialize in offering support to microcomputer users.

Among those surveyed, most reported under 10 users of a particular microcomputer, these users being equally divided among programmers, analysts, and clerical persons. Some microcomputers are being used exclusively for activities such as analysis or word processing; the staff involved reflect this utilization.

## 4.7 Marketing

### 4.7.1 Microcomputer Systems

The microcomputer market is crowded and confusing. The vendors, old and new, are jockeying products and prices to grab a share of the market. In order to understand the marketing scene, one must look at who is buying microcomputers, who is producing them, how they are sold, how software is developed and priced, and what determines success in the microcomputer market.

Something important is happening in how computers are being bought It used to be that the computer people bought the computer. Now the businessman or businesswoman buys the computer. And they don't buy a computer; they buy an accounts receivable system, a financial management system, a project management system, a personnel management system.(104)

The microcomputer market has been noticeably different from the rest of the computer industry. Instead of companies like Wang Laboratories, Inc., Digital Equipment Corp., and IBM as industry leaders, until recently one found Tandy's Radio Shack, Apple Computer, Inc., Commodore Business Machines, and dozens of others.(105)

However, after sitting on the sidelines during the 8-bit era many traditional mainframe and minicomputer manufacturers are now rushing into the market. They join the established vendors and dozens of new startups in competing for what may well be the technology growth market of the 1980's.(106)

IBM's entry into the microcomputer market with the Personal Computer (PC) has had a profound effect. Cary Lu, of <u>High Technology</u>, predicts that IBM will enjoy a substantial lead in software and hardware accessories for some time; in fact, the competition may never catch up.(107) IBM competitors are trying one of two tactics: either promoting their microcomputers in terms of how they correct the deficiencies in the IBM PC, or emphasizing that their products are compatible with the IBM PC, able to run exactly the same programs in exactly the same way. The reader should be aware that many claims to compatibility go no further than a look-alike keyboard; this makes it imperative to verify the degree of compatibility if a particular compatibility requirement exists.

As mentioned in a previous chapter, Adam Osborne was among the first microcomputer vendors to market a package consisting of hardware and software. In doing so he is selling the software at prices far below what it would command on the open market. But the total volume of sales is the bottom line. Others are following Osborne's example.

#### 4.7.1.1 Options for Purchase

Buying a microcomputer doesn't require scheduling a visit from a sales representative armed with literature. Instead, a potential user may choose to order by mail, go to a retail store that sells microcomputers, or even buy from a door-to-door salesperson.

#### 4.7.1.1.1 Mail Order

By looking through a current microcomputing magazine, one can see that the way to cut cost is to order by mail. The first microcomputers were purchased by mail order. Companies, such as Sinclair Ltd., have successfully continued to use this as their primary means of distribution. However, mail order meets the needs of only a small number of potential consumers who are very sure of what they want. In addition, one can never be assured of the stability of mail-order establishments. Recently an aggressive Southern California discount computer store that claimed to be the largest dealer of Apple computers in the U.S. filed for bankruptcy, leaving a string of angry customers who had made deposits and had not received their equipment.

#### 4.7.1.1.2 Independent Retail Stores

Independent retail stores, such as Computerland, account for the greatest percentage of market sales. Computerland now has 250 stores in the U.S. and is seemingly unaffected by increased competition. The approach taken has been to take a well-funded dealership, stock it with a variety of manufacturers' products, staff it with knowledgeable people, and advertise heavily.(108) In actuality, there is a definite shortage of knowledgeable people; stores are forced to accept salespersons with less than adequate backgrounds.

#### 4.7.1.1.3 Company-owned Retail Stores and Door-to-Door Sales

Now company-owned retail stores account for the second largest piece of the marketing pie. Xerox, IBM, and DEC now have their own stores in major cities throughout the U.S. Meanwhile, a Texas entrepreneur has started a network of door-to-door salespersons. These distributors become familiar with the systems by using them; then they take to the road. The company stakes its success on the personal attention given to the potential user.

#### 4.7.1.2 Market Split

The current market is fast-growing and changing. In October, 1982, the following distribution of sales was given by Edward Jones in Desktop Computing: 45% independent retail stores, 26% company-owned retail stores, 13% distributed by manufacturers through direct sales force, 10% mail order and direct to end user, 6% others.(109)

### 4.7.2 Software Market

The production and marketing of microcomputer software are unique in their own right. Graham M. Campbell, of the Small Systems Editorial Board, comments: "I've seen enormous microcomputer packages developed by one or two people, right down to the documentation; minicomputer packages almost the same size or smaller seem to involve whole teams of people."(110)

Micro software development has been a cottage industry. Although companies like Digital Research and Visicorp are responsible for a large chunk of the market, their products are not always superior to those of very small firms.

Third-party software vendors adapt their packages for hardware systems based on their perception of the current or future market share of those systems. For many such vendors, the strong entry of the IBM PC and its subsequent sales record were probably a great relief. It gave them a more stable target to which their endeavors could be aimed.

However, Cary Lu, of High Technology, suggests that many software developers, including some of the biggest names, have only the most pedestrian ideas of how to use the new computer power. Because their first-generation products sell well, they are making just the minimum allowance for the new micros. If these companies do not change, they will not survive.(111)

Some vendors seek to control their product and compel users to buy accessories only from them. A proprietory bus or operating system are examples of this. This approach has the potential to backfire, as it did for Atari and Texas Instruments. Secrecy does not invite software developers; without software, few buyers are interested. Companies would probably do well to disclose whatever information is necessary to attract software development, including publishing the basic input/output system, or BIOS, the kernal of any operating system.

The question of software pricing is a real attempt at modeling. Werner L. Frank, of Computerworld, postulates a four-to-one reduction in sales volume resulting from doubling in price. If he is correct, then the author and distributor or dealer are likely to derive significant benefit from low unit prices. In addition to increasing sales volume, lower prices facilitate market penetration. This in itself is a positive factor in establishing the product. Market share begets more sales on its own account, and once the product is well established, there is always the prospect of raising the price to obtain further advantages.(112)

### 4.7.3 Current Market Characteristics

Popular notion leads one to believe that the microcomputer revolution was inevitable and was one of the last surges of free entrepreneurial capitalism. Although there are numerous stories of young multi-millionaire Horatio Alger characters in the

microcomputing business, it cannot be denied that true success has involved considerable financial backing and conscious choices among various technological paths.

The proponents of the entrepreneurial explanation see the market as dominated by tiny firms. In fact, even as far back as 1979, the leading American producers of microprocessors were Texas Instruments, National Semiconductor, Intel, General Instrument, and Zilog.(113) These are large companies which do not necessarily even specialize in computer equipment.

Foreign government subsidies could have an interesting effect on the microcomputer market. Japan is currently causing considerable anxiety among American producers by introducing chips of greater capacity and more exacting specifications and quality control. The Japanese government has not only subsidized this production, but has allowed the companies to operate with extraordinary debt/equity ratios -- an industry average of 345% compared to 16% in the U.S.(114) In Britain and in South Korea, joint government-private ventures have been set up to promote the microelectronics industry.

Sol Libes, of BYTE Magazine, has some accurate observations of the current market. He states that there is no doubt that success in the personal computing marketplace now is less a function of having a well-designed product than of having adequate distribution. Apple is far and away the most popular with dealers, probably due to the large amount of advertising done by Apple that, in effect, presells the system for the dealer. Most of the leading systems are made by large companies to whom computers are only a small part of the total business. None of the Japanese suppliers has yet received acceptance from computer stores.(115)

Speculation as to the future of this market is varied. There is no doubt that the total sales will skyrocket; Cary Lu, of High Technology, sees the total sales figure rising from $3.5 billion in 1982 to $14 billion in 1986.(116) As to which products will lead this growth, there is great debate. Some think that powerful 16-bit microcomputers will devastate the word processing market and seriously encroach on the minicomputer market. Others see the 16-bit microcomputer as only an interim machine with 32-bit microcomputers succeeding 8-bit systems as the industry leaders. The direction of software development may well be the deciding factor.

The current market is very much based in the U.S. and other highly industrialized countries. Dealers for companies like Apple, Radio Shack and Commodore are appearing in the larger cities of developing countries. IBM only recently announced its intention to market the PC outside the U.S. The international market has great potential for the future but to date has only been in the periphery for most vendors.

## 4.8 Maintenance

Maintenance is fundamentally the weakest element in the microcomputer industry. While microcomputers are much more reliable than their predecessors, they do sometimes fail. And when they do, service becomes an important consideration. Daniel McCracken presents a comical portrayal of an all-too-frustrating experience in obtaining service for his microcomputer in an article entitled "Maintaining a Grapefruit" in Datamation, April 1982.

### 4.8.1 Options

There are several approaches to serviceability and maintenance support, each of which should be given thoughtful consideration prior to selection of a particular machine or vendor. Among the various approaches are carry-in service, mail-in service, self-service, and on-site service. The choice of service alternatives depends on many factors, among them:

- -- Willingness to be without the microcomputer,
- -- Budget,
- -- Capability to transport the system, and
- -- Ability to perform repairs.

#### 4.8.1.1 Carry-In Service

Carry-in service can be handled under contract, at a reduction of 30 to 50 percent less than an on-site contract, or on a per-incident basis.(117) In many cases, the repair can be made while one waits, although some problems may require that the equipment be left. In some cases, dealers will provide the user with a "loaner" system to minimize downtime while servicing the faulty equipment.(118) The major drawback to carry-in service is that the user must isolate the offending component. This is usually easy to determine, but in some cases it can be very confusing.

#### 4.8.1.2 Mail-In Service

Mail-in service is less expensive than carry-in service, but has the disadvantage of taking time. Most serious microcomputer users cannot afford to be without their system for any length of time. As with carry-in service, it is up to the user to isolate the malfunctioning equipment. If this is the only option, it pays to locate the mail-in depot which will offer the fastest servicing of the equipment. This type of service can be charged at a yearly rate for a contract or at a flat rate for the particular unit returned.

#### 4.8.1.3 Self-Service

Self-service is the least expensive alternative. The user must take into consideration that he is dealing with potentially hazardous voltages of up to 12,000 volts once he removes the cover of his microcomputer.(119) With self-service, the cost is limited

to replacement parts plus the time of the person involved. Effective self-service requires the availability of spare parts. Some vendors are providing built-in and remote diagnostics to assist their customers in locating problems. Self-service is normally best suited to the hobbyist who enjoys working on his system and whose business does not rely on his computer.(120)

4.8.1.4 <u>On-Site Maintenance</u>

On-site maintenance from the vendor or a third-party maintenance company is the most costly, but usually the most thorough, service alternative. A standard hardware maintenance contract covering time and materials and limited to normal work week hours should carry monthly costs of about 1% of the initial purchase price of the hardware. This type of contract should include wording to cover the unfixable machine as a guarantee to the user. Some users elect to pay for service on a time and materials basis, as needed. Fees typically range from $25 to $100 per hour with no guarantees other than warranty on parts used.(121) On-site maintenance may be the only viable service alternative for businesses that rely heavily on their microcomputers.

4.8.2 <u>Maintenance Strategy</u>

Maintenance strategy in each of these alternatives differs radically from the approach taken with mainframe computers. Probably the primary service tactic for most companies over the last 4 or 5 years is "board swapping" which does not rely on field engineers. Once the problem has been isolated to the board level, a replacement board is simply substituted for the offending board. This same process can be extended to the chip level, where replacement chips can be substituted until the problem is rectified.

As the cost of hardware continues to decline, maintenance may take on an entirely new light. In a recent report by the International Data Corporation of Framingham, Massachusetts, it is surmised that society could reach the stage where it is cheaper to throw the product away than have it repaired!(122)

4.8.3 <u>Current Maintenance Practices</u>

The survey of users conducted as part of this study indicated two basic groups: those whose microcomputers had never had any problems and those who had had difficulty in obtaining service. It was suprising to find some users in the first group whose machines were two years old! This attests to the reliability of microcomputers in general.

The survey further indicated that developing country users rely either on mail-in service or self-service when they need maintenance. Mail-in service from remote areas has resulted in long delays in processing. Furthermore, it has been difficult to assure against further damage in transit. The United Nations went to the extreme of having special metal cases constructed for each

microcomputer component it supplied for the sole purpose of protection in transit.

Self-service among developing country users is being used more and more. They are realizing that they can successfully perform board-swapping and chip-swapping if they have the proper spare parts. Unfortunately, not all problems can be remedied by board- or chip-swapping.

## 4.9 Advantages and Disadvantages

Perhaps it would be useful to conclude this chapter on microcomputer technology with a summary of the advantages and disadvantages it has to offer. It seems that far more advantages than disadvantages can be cited.

### 4.9.1 Advantages

The small number of components required by a microcomputer system result in several advantages:

- -- Reduced physical volume and system miniaturization, in some cases resulting in portability;
- -- Reduced power consumption;
- -- Reduced power dissipation (implying less heat); and
- -- Increased reliability because of a smaller number of components.(123)

The above characteristics result in a substantially lower cost, especially if the number of units produced is high. The same characteristics have reduced the environmental requirements. The reader is referred to the discussion of cost and environment provided above.

Ease of use is the most often cited advantage of microcomputers. Microcomputers do not necessitate the introduction of new experts into organizations. "User friendly" software has resulted in the fact that persons without data processing experience are in many cases the end users. The majority of microcomputer users today are using this packaged software which leads them through solving their problems.

Because of their simplicity and their environmental freedom, microcomputers (especially those purchased as off-the-shelf systems) are easy to install. A user can be productive the same day the system arrives. In addition, there is no need to train an operator; the end-user is the operator.

The microcomputer gives the user total control. The data, hardware, and software are completely controlled by the user. He can dictate the schedule of his machine's users or choose to have no schedule! At the same time this freedom places a greater responsibility on the user in many ways. But most users very willingly take this on.

The user doing research and development or exploratory data analysis benefits from the ability to try different approaches in an interactive environment and quickly see results. He may call upon graphics capability to provide greater understanding of his data.

Some software packages facilitate programming by providing a shell into which users can make additions. T.W. Collins mentions Scientific MicroPrograms as one such package. This package was intentionally designed to make the addition of new subroutines as easy and nondisruptive as possible. In addition, there are program generators, such as the Pearl, which generate a complete customized program with minimal input on the part of the user. The reader is warned that the reduced programming effort needed to use this type of software may be accompanied by serious restrictions in capability.

Another advantage of the microcomputer is its versatility. Microcomputer workstations are multifunctional. The microcomputer can act as a terminal providing access to large mainframe computers. It can inquire into mainframe data bases, serve as an input device for transaction processing, collect transactions locally for later transmission to a host, or receive data from the host and store it for later manipulation or display.(124)

The last area of advantage deals with getting away from the large commitments implied by mainframe computers. Investments in large computers tie organizations to specific operating systems and particular kinds of computer technology. In addition, there are often long delays in getting new mainframe computers because of the size of the procurement.

### 4.9.2 Disadvantages

The disadvantages of microcomputers are not as numerous but can be serious, depending on the application involved. These include storage, speed, and support limitations; custom implementation problems; and security issues.

Microcomputers are undeniably slower than mainframe computers. It may be more correct to look at speed as job turnaround time, instead of processing time. In many cases the mainframe CPU is faster, but demands for I/O peripherals or delays in getting output to the user actually favor turnaround time on a microcomputer. In any case, if large quantities of data are involved, speed may be a serious problem for the microcomputer user.

Primary storage limitations have probably been the biggest disadvantage to microcomputer users. Most 8-bit systems have a memory limit of 64K bytes of which a portion is not available to the user. This restriction has forced a return to program overlays, segmentation, and dividing large programs into smaller ones. The newer 16- and 32-bit microcomputers are alleviating the storage problem, to some degree, commonly allowing a megabyte or more of memory.

User support is somewhat lacking for most microcomputers. The technology is so new and so many different vendors are involved in supplying the pieces of hardware and software that it often becomes difficult to figure out to whom to address a question or problem. As the technology becomes better established, the user community will demand a more substantial support system than currently exists.

Program development on microcomputers has not reached the level of stability it has on mainframe computers. This does not reflect on microcomputer programmers, but rather on the fact that the software tools and accompanying documentation have not yet undergone the thorough shakedown they need. Unexplained errors occur; certain things function differently than one would expect from the documentation; operating systems are still somewhat primitive. Therefore, the person who must write custom programs will probably not experience nearly the degree of user friendliness as the person who uses a menu-driven software package.

Although having data at a person's fingertips has its advantages, the security implications are obvious. Control of information becomes much more difficult because of the accessibility to data and the ease with which it can be copied.

### 4.9.3 User Survey

The user survey showed an overwhelming agreement with the advantages cited above. On the other hand, a fourth of the users expressed problems with speed and nearly half had serious storage problems. In addition, several people thought it was difficult to begin using the microcomputer with no data processing experience.

## FOOTNOTES

1 Carol Anne Ogdin, Microcomputer Management and Programming (Prentice Hall, Inc.: Englewood Cliffs, NJ, 1980), pp. 9,10.

2 Nancy Love, "Microcomputer Standards Process Runs Gamut from Frustration to Fruition," Mini-Micro Systems, Vol. XV, No. 7 (7/82), pp 135ff.

3 "Bytelines", BYTE, Vol. 7, No. 1 (1/82), p. 298.

4 Rodnay Zaks, From Chips to Systems (Berkeley: Sybex,1981), p. 388.

5 Leland W. Slater, "Everything You Ever Wanted to Know About Microcomputers," Computopics, 3/82, pp. 38ff.

6 Zaks, From Chips to Systems, pp. 124ff.

7 Vardell Lines, Minicomputer Systems (Winthrop Publishers, Inc.: Cambridge, 1980), p. 46.

8 Christopher Kocker and Michael Keith, "Six Personal Computers from Japan," BYTE, Vol. 7, No. 5 (5/82), pp. 92-100.

9 Gregg Williams, "A Closer Look at the IBM Personal Computer", BYTE, Vol. 7, No. 1 (1/82), p.36.

10 See Steve Leibson, "The Input/Output Primer, Part 2: Interrupts and Direct Memory Access", BYTE, Volume 7, No. 3 (3/82), p. 126.

11 Steve Leibson, "The Input/Output Primer: Part 4: The BCD and Serial Interfaces", BYTE, Vol. 7, No. 5 (5/82), pp. 202ff.

12 Steve Leibson, "The Input/Output Primer: Part 3: The Parallel and HPIB (IEEE-488) Interfaces", BYTE, Vol. 7, No. 4 (4/82), pp. 186ff.

13 "Bytelines," BYTE, 6/82, p. 446.

14 Paul E. Schindler, Jr., "Multiple Sub-5.25-Inch Floppy Designs Foreseen", Information System News, 1/10/83, p. 29.

15 James N. Porter, "Floppy-disk Drives: A Truly Flexible Industry Standard", Mini-Micro Systems, Vol. XV, No. 2, 2/82, pp. 165ff. This article includes a complete listing of currently available floppy disk drives together with the disk capacity and other related facts useful in selecting a drive. Compare also the report "Magnetic Media: What's Available; What's in Store" from Computerworld, Vol. XVI, No. 11 (3/15/82), In Depth, p.1

16 Jerry Pournelle addresses this problem in characteristically understandable terms in his September article in BYTE: Jerry

Pournelle, "Letters, Pascal, CB/80 and Cardfile", BYTE, Vol. 7, No. 9 (9/82), pp. 320-324.

17 James N. Porter, "Rigid Disks: The New Small System Alternative", Mini-Micro Systems, Vol. XV, No. 2 (2/82), pp. 145ff.

18 Grover Mullin, "Mixing Disk Drive Ingredients for Your Applications", Mini-Micro Systems, Vol. XV, No. 11 (11/82), p. 286.

19 Tom Makmann, "Winchester Backup For Less Than 'Six Bits' (75 cents) Per Megabyte," Mini-Micro Systems, Vol. XV, No. 8 (8/82), p.213.

20 Jason H. Gordon, "Choosing the Best Tape Drive," Mini-Micro Systems, Vol. XV, No. 10 (10/82), pp. 245ff.

21 Makmann, Winchester Backup, p. 215.

22 Gordon, Best Tape Drive, p. 248.

23 The exception to this is the microcomputer system with memory-mapped input/output where the terminal is replaced with a keyboard and cathode ray tube (CRT) monitor. Both the Apple II and the IBM PC are examples of microcomputers having memory-mapped input/output. With a memory-mapped system an image of the video display is stored in the main memory of the microcomputer itself rather than in the memory of a terminal. There are both advantages and disadvantages to the memory-mapped approach. The primary disadvantages are that the system is generally restricted to a single user and that some portion of memory must be relinquished to support the video display. The great advantage of this approach is that it adds considerable flexibility to the way in which the video display may be used.

24 "Alphanumeric Terminal Market Overview", Mini-Micro Systems, Vol. XV, No. 11 (11/82), pp. 350ff.

25 William J. Catacosinos and John Witherow, Selecting A Low-End Display Terminal", Mini-Micro Systems, Vol. XV, No. 11 (11/82), p. 365.

26 WordStar Installation Manual, (MicroPro International Corp.:San Rafael, California, 1981), p. 201

27 There are excellent articles in the literature describing the operation and capabilities of the various technologies. A good starting place would be an evaluation of peripherals published by Mini-Micro Systems in November 1982 (Vol. XV, No. 11).

28 For an example of a color printer see Ed Umlor, "Integral Data System's Prism Printer," BYTE, Volume 7, No. 3 (3/82), pp. 44-49.

29 There is a brief but excellent treatment of the modem dilemma in the response to a letter to the editor of BYTE in the June issue of 1982 (p. 42).

30 Elizabeth Horwitt, "Let Your Computer Really Reach Out," Business Computer Systems, September 1982, pp. 107ff.

31 Herb Brody, "Machines That Read Move Up a Grade," High Technology, Vol. 3, No. 2 (2/82), pp. 35ff. See also, Bruce W. Johnson, "OCR Advances Widening Applications Horizon," Computerworld, Vol. XVI, No. 48, pp. 9f.

32 Bruce Hoard, "Local-Area Network Standards: The Long Wait," Computerworld, Vol XVI, No. 52 (12/27/82), p. 42.

33 George Kotelly, "Personal Computer Networks," EDN, Vol. 28, No. 5 (3/3/83), pp. 83-100.

34 EDN, Vol. 27, No. 15 (8/4/82), p. 208.

35 Computer Design, Vol. 21, No. 5 (5/82), p. 326.

36 For further information, see Amy F. Smith, "Power Line Perils", Business Computer Systems, September 1982, pp. 120-126.

37 See John Tsantes, "Power Sources," EDN, Vol. 27, No. 24 (12/17/82), pp. 340ff.

38 E.B. James, "The User Interface: How We May Compute," pp. 338f. from Computing Skills and the User Interface, M.J. Coombs and J.L. Alty, eds., (Academic Press:London, 1981).

39 Louis Fried, "Nine Principles for Ergonomic Software", Datamation, Vol. 28, No. 12 (11/82), pp. 163ff.

40 George Kotelly, "EDN's Third Annual Microcomputer Operating Systems Directory," EDN, Vol. 27, No. 18 (9/15/82), pp. 81ff.

41 John Wharton and Gary Kildall, "The CP/M Operating System: A Universal Control Program for Eight-bit Microcomputer Systems" from Microprocessor Operating Systems, Volume II, John Zarella, ed., (Microcomputer Applications:Suisun City, California, 1982).

42 David Simpson, "Small-Business Systems Solve Big Problems," Mini-Micro Systems, Vol. XV, No. 6 (6/82), p. 204.

43 Mark Overgaard, "Implementing the UCSD p-System," Mini-Micro System, Vol. XV, No. 9 (9/82), p. 190.

44 Ibid., p. 184.

45 Malcolm Blackhall, "The Multiuser OASIS Operating System: A Multiuser, Multitasking Operating System for the Z80," Microprocessor Operating Systems, Vol. II, op cit.

46 "Bytelines", BYTE, Vol 7, No. 6 (6/32), p. 442.

47 Ibid., p. 442.

48 Roger Taylor and Phil Lemmons, "Upward Migration: Part 2: A Comparison of CP/M-86 and MS-DOS", BYTE, Vol. 7, No. 7 (7/82), p. 330.

49 Ibid., p. 334.

50 "Bytelines", BYTE, Vol. 7, No. 6 (6/82), p. 442.

51 Phil Hughes, "The Operating System of the Future," Microcomputing, Vol. VI, No. 6 (6/82), pp. 28ff.

52 Robert B. Greenberg, "The UNIX Operating System and the XENIX Standard Operating Environment," BYTE, Vol. 6, No. 6 (6/81), pp. 248ff.

53 Rebecca Anne Thomas and Jean Yates, "UNIX," Computerworld, Vol. XVI, No. 2 (1/11/82), In Depth, pp. 17ff.

54 Donald A. Norman, "The Trouble with UNIX," Datamation, Vol. 27, No. 12 (11/81), pp. 139ff.

55 Kotelly, Personal Computer Networks, p. 85.

56 Thomas E. Kurtz, "On the Way to Standard BASIC", BYTE, Vol. 7, No. 6 (6/82), p. 182.

57 An extensive list of language time trials is included in the article "Eratosthenes Revisited: Once More through the Sieve", by Jim and Gary Gilbreath in BYTE, Vol. 8, No. 1 (1/83), pp. 283ff.

58 Kurtz, Standard BASIC, p. 182.

59 Ronald Anderson, "The Proposed ANSI BASIC Standard," BYTE, Vol. 8, No. 2 (2/83), p. 196.

60 Seymour Papert, Mindstorms (Basic Books:New York,1980) p 34.

61 Thomas Doyle, "Pascal Standards," BYTE, Vol 7, No. 2, p. 322.

62 See also Thomas H. Woteki and Paul A. Sand, "Four Implementations of Pascal," BYTE, Volume 7, No. 3, (3/82), pp. 316ff.

63 Kenneth Magel, "A Report on a Pascal Questionnaire," ACM Sigplan Notices, Vol. 17, No. 10 (10/82), pp. 23ff.

64 Kotelly, Personal Computer Networks, p. 82.

65 As an example see Jerry Pournelle, "A Slew of Languages, a Slap at Documentation and a Curse at Keyboards," BYTE, Vol. 7, No. 12 (12/82), p. 244.

66 Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language (Prentice-Hall, Inc. : Englewood Cliffs, NJ, 1978).

67 John A. Lehman, "PL/I for Microcomputers," BYTE, Vol. 7, No. 5 (5/82), pp. 246ff.

68 Gilbreath, Eratosthenes Revisited, p. 298.

69 William E. Carlson and David A. Fisher, "First Complete Ada Compiler Runs on a Micro," Mini-Micro Systems, Vol. XV, No. 9 (9/82), pp. 207ff.

70 James Fawcette, "Ada Tackles Software Bottleneck," High Technology, Vol. 3, No. 2, (2/83), pp. 49ff.

71 See Jerry Pournelle, "Semidisk, Software Tools, the BDOS Blues, Power and LISPs," BYTE, Vol. 7, No. 8 (8/82), pp. 360ff.

72 Gregg Williams, "Three Versions of APL," BYTE, Vol. 6, No. 4 (4/81), pp. 188ff.

73 Patrick Kenealy, "Database Software Packages for Micros," Mini-Micro Systems, Vol. XV, No. 9 (9/82), p. 193.

74 Robert L. Akers, "Database Scorecard," Microcomputing, Vol. VI, No. 4 (4/82), pp. 52ff.

75 For a comparison of packages available at the lower end of this spectrum see Donna Stein, "Your Business Image," Business Computer Systems, 11/82, pp. 63ff.

76 For a description of the Beacon see Bert Latamore, "A Graphic Display," Desktop Computing, Vol. 2, No. 12 (12/82), pp. 8-15. A comparison of business graphics software packages can be found in Mini-Micro Systems, Vol. XV, No. 7 (7/82), pp. 218-224.

77 Patrick Kenealy, "WP Software Advances Rapidly," Mini-Micro Systems, Vol. XVI, No. 5, (5/82), pp. 171-190.

78 Ibid., pp. 177-178. See also, Elizabeth Horwitt's "The Wonders of Word Processing", Business Computer Systems, 11/82, pp. 79ff., and Arthur Naiman's "Word Processing: How Packages Stack Up," Business Computer Systems, 4/83, pp. 51ff.

79 Bytelines, BYTE, Vol. 7, No. 6, (6/82) p. 444.

80 Donna Stein, "The Calc Wars", Business Computer Systems, 9/82, pp. 69ff.

81 Mike Wingfield, "Build an Intercomputer Data Link," BYTE (April 1981), p. 252.

82 Gregory A. Marks, "Microcomputers: Basic Choice Factors" (The University of Michigan, June 1982), p. 21.

83 Ibid.

84 Jeffrey Stone, "Microcomputer Selection Study," (World Bank, July 16, 1981). p. 46.

85 Ibid., p. 46-47.

86 Ibid., p. 47.

87 Ibid.

88 Ibid.

89 Marks, Choice Factors, p. 21.

90 Cary Lu, "Microcomputers: The Second Wave," High Technology (September/October 1982), p. 50.

91 John Torode, "Getting Down to Business with Local Area Networks," Microcomputing (June 1982), p. 32.

92 T.W. Collins, "Social Science Research and the Microcomputer," Sociological Methods and Research, Vol. 9, No. 4 (May 1981), p. 444.

93 E.B. James, "Thoughts on Networking" (Imperial College, 1982).

94 Andrew J. Stephens, "Microcomputers in Developing Countries," (MSU Conference, 1982), p. 2.

95 Lu, Second Wave, p.52.

96 Sinter, Everything You Ever Wanted to Know About Microcomputers, p. 52-53.

97 Smith, Power Line Perils, p. 121-122.

98 E.B. James, "Personal Computing Systems for Research and Development," (Imperial College, January 1981), p. 6-7.

99 Zaks, From Chips to Systems, p. 31.

100 Lu, Second Wave, p. 40.

101 Fidelis M. Umeh, "Small Systems World Editorial Board Holds Roundtable Discussion on Key Topics," Small Systems World (July 1982), p. 17.

102 James, Systems for Research and Development, p. 5.

103 Ibid., p. 25.

104 Roger L. Schelm, Small Systems World Editorial Board, p. 20.

105 Elizabeth M. Ferrarini, "Invasion of the Microcomputers," Computerworld (June 1, 1981), In Depth p. 13.

106 Lu, Second Wave, p. 39.

107 Ibid., p. 40.

108 Edward Jones, "Shopping Around," Desktop Computing (October 1982), p. 64.

109 Ibid., p. 65.

110 Graham M. Campbell, Small Systems Editorial Board, p. 18.

111 Lu, Second Wave, p. 40.

112 Werner L. Frank, "Micro Software / Hardware: The Profit Picture," Computerworld (September 18, 1982), p. 61.

113 The Economist (May 12, 1979, and August 2, 1980) cited by Craig J. Calhoun, "The Microcomputer Revolution," Sociological Methods and Research, Vol. 9, No. 4 (May 1981), p. 404.

114 The Economist (February 23, 1980) cited by Calhoun, Microcomputer Revolution, p. 406.

115 Sol Libes, "Bytelines," BYTE (June 1982), p. 440.

116 Lu, Second Wave, p. 52.

117 John Butler, "Hard Facts on Hardware Service," Desktop Computing (March 1983), p. 60.

118 "Servicing Your Systems, "Datapro Small Computer News (July 1981), p. 1.

119 Butler, Hard Facts on Hardware Service, p. 61.

120 Ibid.

121 Datapro: Servicing Your System, p. 1.

122 Marguerita Zientara, "User-Maintenance Alternatives Abound," Computerworld (February 1983), p. 11-12.

123 Zaks, _Chips to Systems_, p. 31.

124 "Flourishing Micros Offer Real Advantage," _Computerworld_ (August 30, 1982), Special Report p. 8.

# CHAPTER 5: CURRENT MICROCOMPUTER APPLICATIONS

A discussion of how microcomputers are being used would seem an appropriate chapter to follow a discussion of the technology. It is hard to appreciate their penetration of our society without some concrete examples of actual applications. The difficulty faced in writing this chapter was how to present the material because so many applications are overlapping. Each application has been presented under the category that best depicts it. The categories are arranged alphabetically.

## 5.1 Agriculture

In the last few years, hundreds of applications for microcomputers and hand-held calculators have emerged in the field of agriculture. Dr. J. Robert Strain and Noel Berge, under contract to the U.S. Department of Agriculture, have compiled several comprehensive reports dealing with the use of microcomputers in agriculture management. The latest of these reports is entitled Updated Inventory of Agricultural Computer Programs and can be obtained for $3.50 from the University of Florida, Administrative Services, IFAS - Building 664, Gainesville, Florida 32611 Some concrete examples of the use of microcomputers for agriculture applications follow:

-- Farmers are in the vanguard of professional use of microcomputers, keeping inventory and weather records and forecasting casting market trends.(1)

-- Engineers in Australia are nearing their target of devising a fully automated mechanism for shearing sheep. The Australian Wool Corporation embarked on the project because of the high cost of shearing sheep by hand. The final product will be a "robot" shearer that operates without nicking the animal.(2)

-- Orlando Espadas of Bolivia has developed a system based on the HP-85 for ranch management. It started with herd projections and has progressed to include several crop-oriented components.

-- Andrew James, of the University of Reading's Veterinary Epidemiology and Economics Research Unit, is managing a project in Nairobi, Kenya, which utilizes two Digital MicroSystems to handle cattle dip monitoring, F.M.D. control monitoring, and other applications. Similar applications will soon be implemented in Colombia with James' help.

## 5.2 Business

The business community constitutes the greatest number of users of microcomputers. The primary business use of microcomputers is to keep and later gain access to records of various sorts. Microcomputer systems costing between $4,000 and $8,000 are

increasingly the basis for record-keeping among professionals such as doctors and lawyers. Such computer file-keeping is extremely economical and reliable; it is frequently possible for a microcomputer to save an entire clerical salary and improve response time in searching for particular data.(3)

Some other professional practices, such as architectural concerns, may use the microcomputer for more than simple file-keeping. They rely heavily on graphics and can also benefit by using programs to check various complicated plans.

Business firms often use microcomputers as word processors as well as filing systems. Letters which are repeatedly sent may be stored for access and editing when required; billing is easily computerized. Filing functions are still significant here.

Business software is one of the mainstays of the microcomputer industry. It covers standard business applications, such as basic accounting, data acquisition, inventory reporting and control, and personnel management. It is also available for support applications, such as electronic mail, automated calendars, project management, computer-aided design, decision support systems, graphics, and data base access/retrieval. Several examples of microcomputer use in the business world follow:

-- Computerized cash registers are now being used in grocery stores. Establishing stock on hand no longer requires a separate human step (avoiding lost time if the store must be closed, or overtime wages if the work is done after normal hours).(4)

-- At Bache Halsey Stuart Shields, a large brokerage firm based in New York, a senior vice-president in charge of marketing uses an Apple II microcomputer for keeping records on branch offices and account executives. The data base software used can search and compile a report on any desired selection criterion. For example, the system can compile a report of all the account executives in the Southwest region who have produced a certain amount of business within certain dates.(5)

-- Arthur Young & Co., one of largest U.S. public accounting firms, has opted for using Apple II microcomputers instead of timesharing for applications such as loan and lease amortization, discounting and present value, cash flows, and random sampling.(6)

-- Planning tools allow the user to manipulate and display the parameters underlying various models, often of a financial nature, and to experiment with alternatives. Microcomputers greatly facilitate the preparation of spreadsheets which contain the parameters for the models. The user may quickly explore differing budgets, allocations of resources, or the impact of new information

on an earlier model.(7) He can address "What if" scenarios such as the following:

-- If I begin renovations on my selling floor now, what happens to my cash position next month?
-- What should we change for our new product if the cost of raw materials goes up by 40 percent in the next quarter?
-- What do we save in the personnel budget if we freeze salary increases next year?

5.3 Data Processing; Statistical Applications

This area of application encompasses a broad base of activities, including data entry, editing, tabulation, report generation, and analysis of data. It has perhaps received the least attention from software developers because of its general-purpose nature and because of the quantity of data often involved in censuses and surveys, in particular.

Statistical software of appropriate quality has only recently begun to appear for microcomputers. This is partly because the hardware has previously not been fast enough to do the statistical calculations in reasonable times, partly because data storage capacity has also been very limited, and finally because relatively large and complex programs are involved.(8)

Many examples of this type of processing on microcomputers are starting to emerge, among them the following:

-- The Agricultural Projects Monitoring, Evaluation and Planning Unit of the Government of Nigeria is using at least 8 Apple microcomputers to enter data at project sites throughout the country. This decentralization has greatly speeded up the availability of data.

-- A combination of Hewlett-Packard mark sensing equipment and a TRS-80 Mod II are being used to process data collected in a labor usage survey in Egypt. The system processes 1600 cards per week.

-- Data entry and initial editing of the Puerto Rican Economic Census is being done on a networked system of 10 Apple II microcomputers, under the direction of the U.S. Bureau of the Census. The data are being collected from 26,000 establishments.

-- Two U.S. Census advisors to Bangladesh used an Apple II+ with the software package DB Master to process an economic survey of about 800 respondents with 94 fields in each record. The processing was very slow and tedious, but it was completed.

-- The U.S. Department of Agriculture has supplied North Star microcomputers and the software necessary to process

agriculture surveys in Jamaica, Ecuador, Morocco, Tunisia, Sierra Leone, the Philippines, Liberia, and Sudan.

-- Purdue University utilized TRS-80 microcomputers to support the initial processing of agriculture survey data by 15 researchers in Francophone Africa. This has resulted in many data sets which contain over 60,000 cases.

-- The United Nations has installed microcomputer systems in the Cape Verde Islands, the Comoros Islands, Sao Tome and Principe, and the Cook Islands for processing national censuses of housing and population.

-- The national statistical office in Ecuador is using 9 Alpha Micro systems, each having 7 terminals, to process their national census data.

## 5.4 Education

The field of education has virtually unlimited applications for microcomputers. Computer-assisted instruction (CAI) is essentially a matter of data management. The computer simply needs to be able to provide its student with some specific sorts of information in an orderly fashion. Microcomputers provide several real advantages in this area:

-- They are small enough and cheap enough that individual students can use them when and where they choose.

-- Microcomputers offer much more rapid response time than did the original CAI machines of the 1960's.

-- Microcomputers offer their student the possibility of pursuing a variety of different courses of learning, which takes on a new dimension if the student can program for himself.(9)

LOGO is a computer language which was developed to provide an environment which allows learning to take place as naturally as possible. The LOGO language was designed by Seymour Papert and his colleagues to provide an environment in which the child/learner is in charge of setting a problem to solve; making choices; playing with the problem by experimenting and trying out solutions; and building on what he has already done to do something more.(10) The learner uses "turtle geometry" to implement his ideas. He essentially programs a turtle to follow his commands on the microcomputer screen. One of Papert's objectives was to make learning about mathematics and computers so much fun that our culture's mathephobia would disappear.

## 5.5 Engineering

As an example of the application of microcomputers in the field of engineering, nine Apple microcomputers are used for a variety of applications at Johns-Manville, a Fortune 500 manufacturer of

building materials. Using software they developed, engineers predict at what point condensation will occur within a built-up roofing system. Milton Trosper, a district engineer for the company, said this application eliminates a designer's putting the installation in the wrong place.(11) In addition, the company uses the Apples to support numerous management functions.

## 5.6 Government

Applications at even the lowest levels of government are beginning to appear. For example, an electronic voting machine based on microprocessor technology will be used in elections in Kerala State, India. The machine has been designed and produced by Bharat Electronics Ltd. and consists of two units: one control unit which stays with the polling officer and a balloting unit which is placed in the polling booth from where the voter will cast his vote. Less than 10 percent of the components must be imported.(12)

## 5.7 Health

Some of the most interesting microcomputer applications are coming from the health field. In this area microcomputers have great potential to significantly enhance health statistics and even to improve the quality of life. The following examples are offered:

-- The International Center for Epidemiologic and Preventive Ophthalmology is studying two methods of delivering Vitamin A supplementation to preschool-age children in Indonesia as a means of preventing xerophthalmia, a potentially blinding eye disease. They are using Osborne microcomputers for data entry and initial editing by staff in Jakarta.

-- The International Fertility Research Program is using Texas Instruments microcomputers to facilitate processing data on clinical trials and maternity monitoring in Tunisia, Indonesia, and Thailand. There are requests for similar systems in 50 other countries. They are using customized software written primarily in FORTRAN.

-- Microcomputer-assisted diagnosis is being used by paramedics aboard the U.S. Polaris fleet. They use a software package developed in the U.K. to help diagnose the cause of stomach and chest pains among the crew. The package consists of two small BASIC programs which will run on any CP/M machine. This system, known as de Dombal's system because of its primary author, is being used by doctors in 26 countries. De Dombal says that this amounts to giving the poorest doctors, in the poorest hospitals, in the poorest parts of the world, direct access to the expertise of hundreds of their colleagues for the cost of a microcomputer system.(13)

-- Microcomputers are aiding paraplegics to walk again. Dr. Jerrold Petrofsky, of Wright State University in Ohio, is using an Apple II+ in a research project aimed at making

paralysis victims ambulatory by sending sensory messages which bypass the person's spinal column. The next phase will be to miniaturize the hardware and software so that it is quite portable or can even be implanted in the person's body.

## 5.8 Monitoring and Industrial Control

Automation is touching more and different kinds of activities, with less and less need for human intervention. The major limiting factors have been insufficient precision and flexibility in the motions of automata, and an incapacity for the machines to respond to changes in their environments. Recent microelectronic and related technology has overcome many of the limits imposed by these factors. For several years microprocessors have been able to instantly process quite complex equations to control detailed motions. They are important in electronics, automobile, and computer production, to name only a few areas of application.(14) Some concrete examples of the diverse monitoring and control applications follow:

-- At the University of Cincinnati a microprocessor based wind measurement device has been developed. Existing methods, generally involving arrays of propellor driven meters, are expensive, require complex communications facilities, and can produce ambiguous results. Besides solving these problems, the microprocessor device offers the option of storing collected data or displaying it immediately, can detect line faults, and allows the recording units to be polled at any time. The service is thus more flexible and reliable.(15)

-- A microprocessor-controlled real-time ocean wave analysis system was developed by the University College Galway for a study in Ireland. Requirements for the system were the ability to measure waves at four offshore sites and to calculate average wave heights and periods. The system was operated in remote location and attended by nontechnical personnel.(16)

-- At the British Leyland Land Rover engine plant, microcomputers control the component stores, engine assembly, engine testing, and management information systems to handle engine build schedules, attendance recording, and data network control. The systems reportedly are flexible enough to be used by firms of any size and are being marketed by another British Leyland company.(17)

## 5.9 Personal Use; Games

With declining cost and increasing power, microcomputers have become increasingly attractive for use in the home. Members of the family may have diverse needs which are met by microcomputers, as the following examples demonstrate:

-- A homeowner uses a microcomputer to review a set of summary statistics from past records for home energy consumption. It is interesting to prepare graphs of energy used by month for several years. Perhaps the homeowner wishes to see if home improvements such as storm windows have made a difference.

-- A person interested in investment opportunities uses his home computer to enter data on selected stocks and commodities. He calls up the records on a particular stock and uses some type of forecasting model to predict the stock's price at a future time. For those stocks that are actually bought and sold, the data base can serve as a permanent record of the transaction.

-- Games are the most widely produced software for microcomputers. The better ones are useful for getting past the initial stages of unfamiliarity with the computer, as well as for being fun. The many types of adventure-like games are quite challenging mentally, tending to be very involved.(18)

5.10 Research and Development

Research and development can be viewed on many levels, from laboratory experiments to all types of planning and modeling. Microcomputers are important tools to those who are looking for answers in diverse fields, as the following examples illustrate:

-- Microcomputers have had a profound effect on laboratory experiments. Until recently only the largest laboratories were able to have a dedicated computing system to process their results directly or to control particular experiments ments. It is now possible for virtually every laboratory to have a considerable amount of computing power directly on hand. A good design will include access to greater computational power and storage in the form of a central computing facility when required.

-- Transportation planning is a prime candidate for microcomputers. Most transportation analysis requires numbercrunching. With 16-bit microprocessors, many transporation modeling programs written for larger machines can be run effectively on microcomputers.

-- The city of Winnipeg, Manitoba, has put their building permit process on microcomputers. This type of data can be very useful in estimating current populations and growth trends.(19)

-- Under the RAPID (Resources for the Awareness of Population Impact on Development) project, The Futures Group was contracted by the U.S. Agency for International Development to prepare a standard simple economic-demographic model on the Apple II+ computer for numerous nost countries. A

microcomputer and the RAPID software were demonstrated and then left in the countries involved.

-- Argonne Laboratory has converted an energy supply planning model developed by the Bechtel Corporation to run on an Apple microcomputer. This model provides a "quick look" and will be installed in Jamaica, as well as other developing countries.

-- At the International Development Bank, economists are working on a microcomputer model designed to help reduce the risk of exploration for oil by selecting the most economically attractive exploration strategy. Their aim is to minimize the cash outflow for oil imports by Latin American countries.

# FOOTNOTES

1 E.P. Barton, "Applications of an In-Farm Microcomputer for Dairy Herd Management Decisions," Journal of Diary Science, Vol. 62, No. 51 (1979) cited by Calhoun, Microcomputer Revolution, p. 411.

2 New Scientist (September 2, 1982) cited in the Microelectronics Monitor (October 1982), p. 29.

3 Craig J. Calhoun, "The Microcomputer Revolution," Sociological Methods and Research, Vol. 9, No. 4 (May 1981), p. 411.

4 Ibid.

5 Elizabeth M. Ferrarini, "Invasion of the Microcomputers," Computerworld (June 1, 1981), In Depth p. 16.

6 Ibid.

7 Gregory A. Marks, "Microcomputers: Basic Choice Factors," (The University of Michigan, June 1982), pp. 5-6.

8 Ibid., p. 6.

9 Calhoun, Microcomputer Revolution, p. 412.

10 Molly Watt, "What Is LOGO?" Creative Computing (October 1982), p. 112.

11 Ferrarini, Invasion of the Microcomputers, In Depth p. 16.

12 Microelectronics Monitor (July 1982), p. 26.

13 Ibid., p. 24.

14 Calhoun, Microcomputer Revolution, p. 413.

15 "Microprocessor Applications - International Experience," Mini-Micro Software, Vol. 5, No. 2, p. 4.

16 Ibid., p. 6.

17 Microelectronics Monitor (July 1982), p. 24-25.

18 Marks, Choice Factors, p. 7.

19 Robert Stockman, "Microcomputers Stretch the Limits of Planning," Government Data Systems (November/December 982), p. 29.

# CHAPTER 6: ARGUMENTS FOR INTRODUCING MICROCOMPUTERS IN NATIONAL STATISTICAL OFFICES OF DEVELOPING COUNTRIES

Having discussed various aspects of microcomputer technology and looked at diverse representative applications, the question still remains as to whether microcomputers can be used effectively in national statistical offices of developing countries. The answer would seem to be definitely in the affirmative. Microcomputers are eventually going to become as commonplace in developing countries as they are today in developed countries like the U.S.; thus, to recommend anything else would be to deny natural technological advancement.

The argument of staying abreast of technology is hardly compelling in countries where money is scarce and statistics do not command a high priority. The lobbyist for microcomputers in a country such as the typical case described in Chapter 2 would probably have to offer more concrete arguments to win his point. The following ideas could be used to support his case:

-- The introduction of one or more microcomputers would take some of the pressure off the mainframe computer and perhaps allow it to run more efficiently.

-- The availability of "user-friendly" software and simple operating systems has resulted in lower training requirements than for larger computer systems, thus allowing new people to become productive more quickly.

-- If microcomputers proved capable of handling more and more of the workload, it is conceivable that the mainframe could eventually be phased out, thus creating a substantial cost savings in the monthly fee now paid to lease the mainframe computer and in onsite staff requirements.

-- The use of microcomputers for data entry and initial editing permits correction of certain problems without having to search for the source document.

-- Microcomputers would allow program development for and production processing of at least small data collection efforts to proceed much more rapidly.

-- Microcomputers would offer the potential to computerize many activities currently done manually.

-- Microcomputers would allow access to current software for data base management, spreadsheet functions, word processing, graphics, and statistical analyis. The use of such software could substantially reduce the time currently devoted to development of custom programs.

-- Microcomputers have the potential to attract capable employees who are willing to sacrifice high salaries if they can work in a progressive environment.

-- Microcomputers would allow analysts to do at least some of the processing to support their work, thus freeing up scarce programming staff for other tasks.

-- Microcomputers would increase computing capabilities without additional environmental conditioning or the need to hire additional operators.

-- Microcomputers would distribute processing so that equipment failure would not prove so devastating.

-- Because of their low cost one could rely on redundancy of hardware and training of in-house staff for maintenance and thus avoid costly on-site vendor servicing and long periods of down time while waiting for replacement parts.

-- Microcomputers would allow the staff to maximize their productivity and thus reduce the time needed to support various aspects of statistical processing.

These arguments should serve to convince the decisionmakers of the merit of microcomputers for the statistical office. However, once a positive decision is reached, one must look ahead at the alternatives for integrating microcomputers into the existing environment and confront the potential problems which could arise.

# CHAPTER 7: SCENARIOS FOR MICROCOMPUTER INTEGRATION

Ten or 15 years ago decisions regarding equipment were not nearly so difficult. If one wanted to do data entry he selected one of several data entry machines. If he wished to do graphics he bought a plotter. If he wanted to do word processing, he used a typewriter. If he wanted to do statistical computing, he used the services of a mainframe computer.

Microcomputers, by their versatility, have complicated the selection process. There is now the possibility of buying one of many general-purpose microcomputers that can do <u>all</u> of these things. Deciding how to introduce microcomputers into a situation where there are many diverse needs is difficult. Three possibilities will be explored: replacing the mainframe computer, independently enhancing the mainframe computer, and dependently enhancing the mainframe computer via communications or by use of a common output medium.

## 7.1 <u>Replacing a Mainframe Computer</u>

Attempting to replace an established mainframe computer by a microcomputer or several microcomputers is a serious step for any organization. The existing staff already know how to use the mainframe computer. A repository of software has been written for the mainframe computer; it is unlikely that such software would run on a microcomputer without at least some conversion effort. A whole library of magnetic tape associated with the mainframe computer would be useless on the microcomputer unless it included a tape drive. Most microcomputers do not, and, furthermore, there could be incompatibility problems in the tape drives. Basically, the mainframe computer and its associated peripherals, software, data files, and operation have gone through the shakedown that accompanies any new equipment and stabilized. Only in the case of a non-existent mainframe computer or one that was irreparable would one want to contemplate immediate use of one or more microcomputers to do all the work formerly done on a mainframe computer. This is not to say that over time microcomputers could not systematically take over more and more of the work done on a mainframe computer with the possibility of eventually replacing it.

## 7.2 <u>Independently Enhancing a Mainframe Computer</u>

The second possibility for the integration of microcomputers into an agency would be to keep them independent of a mainframe computer. This makes the most sense for applications such as word processing, spreadsheet generation, or activities that have never been computerized before and are likely not to need programs or data from the mainframe computer. The transfer of applications currently running on the mainframe computer to the microcomputer implies not only a conversion of programs and possibly file formats, but also a reentry of programs and data since there is no means of communication between the computers. This is not

significant if only short programs and small data files are involved.

## 7.3 Dependently Enhancing a Mainframe Computer

The option which offers the most flexibility is that of providing for a communications link between the mainframe computer and one or more microcomputers. This can be done in at least three different ways. The first alternative is to use a modem at each communication point and send programs or data over the telephone lines. The second method is to directly wire the computers together. The third means is to identify a magnetic medium which can be read and written by all machines.

### 7.3.1 Using Modems and Telephone Lines

The use of modems and telephone lines has the distinct advantage of allowing the machines to be physically distant. It has a potential problem if the telephone lines are noisy or unreliable.

### 7.3.2 Hardwiring the Computers Together

Hard wiring the computers together by use of an RS-232C interface is not as simple as it might sound. It may require a special cable and will definitely impose a separation limit of perhaps no more than 50 feet.

In either of the two communications alternatives just presented, there is the necessity that the mainframe computer be able to support a terminal. This is achieved through a combination of hardware and software which enables the mainframe computer to send to and receive from a terminal.

As was previously mentioned, a communications software package must be written or purchased to facilitate direct communication between computers. This type of software is often not trivial and its installation can be difficult.

### 7.3.3 Communications via a Magnetic Medium

The third alternative for communications is via a magnetic medium, such as floppy disks. At this point in time only 8" floppy disks would be a possibility since mainframe computers generally do not support smaller floppy disks and, furthermore, a standard exists only for 8" floppy disks. All machines would have to be able to conform to a standard format such as that used by IBM. This method was actually used in Mauritania to provide data exchange between an IBM and Altos microcomputers which were supporting the entry of national census data. The primary disadvantage of this method would be one of speed in that reading and writing floppy disks is generally slow.

### 7.3.4 Advantages

It seems obvious that communications capability greatly enhances the use of microcomputers. It allows operations to be performed where they can be done most efficiently. It supports program development on microcomputers with the possibility of running those programs on other microcomputers or mainframes. Most importantly it provides for the exchange of data. It provides a way out to a larger or differently configured machine if the necessity arises. It can be a comfort to know that one is not bounded by the confines of his microcomputer.

### 7.3.5 The Mythical NSO

In the case of the typical situation described in Chapter 2, the easiest way to approach communications would be the use of floppy disks. This would imply the use of microcomputers which could read and write 8" floppy disks in IBM format. The other option would be to convert the IBM 370/115 into a machine which could support one or more terminals. Given the condition of the telephone lines in most developing countries, it would probably make most sense to hard wire the machines together. Either of these two alternatives would allow the mainframe computer to communicate with the microcomputer.

# CHAPTER 8: POTENTIAL PROBLEMS IN USING MICROCOMPUTERS IN DEVELOPING COUNTRIES

The choice to use microcomputers carries with it the potential for many diverse problems. This chapter is intended to alert the user to some of these problems and offer ideas on how to cope with them. Many of these issues are mentioned elsewhere in this document; however, they are included once again to make the material in this chapter more comprehensive.

## 8.1 Access to Information

Selection of hardware and software may be difficult because of lack of information and experience. Suggestions are offered in the chapters on microcomputer integration, criteria for selection, and software and hardware review. However, they do not deal with the fact that Byte Magazine and other sources of information may simply be unavailable. It is likely that the hardware and software currently represented in a particular country embraces only a fraction of that on the market.

Countries which find themselves in the dilemma of not having enough information available have several possible courses of action. After they identify the needs to be addressed by a microcomputer, they can either send staff abroad to become knowledgeable of the technology or bring consultants in to give them advice. The former solution could provide a much broader education by focusing on a number of vendors and existing applications. It would entail having someone set up an itinerary in the country to be visited. Hiring a consultant (or soliciting technical assistance from some donor agency) allows the person or persons to assess the local situation when making recommendations. It is imperative to identify consultants who are not previously biased toward specific hardware and software, but rather will base their recommendations on the existing needs and resources.

It would seem worthwhile for AID to establish some type of central or regional microcomputer support group to give assistance to developing countries which need information. This service could save these potential microcomputer users time and avoid the common frustration in trying to make good decisions without adequate guidance. The support group could make the initial assessment and then call in a consultant if the situation warranted extensive technical assistance.

## 8.2 Vendor Representation

Most microcomputer companies are not well represented outside their country of origin. Those that are represented are often unable to meet the demands for supply and/or maintenance. For example, Kittell, the authorized Apple agent in Nigeria, has not been able to meet the steadily increasing demand for computer systems; therefore, supplies from this dealer are somewhat erratic and high priced.(1)

However, a country should give first preference to companies which are represented locally. If any of them provide a system capable of meeting the needs of the office, it should be thoroughly evaluated before other systems are considered.

Local representation was an important consideration when the statistics office in Ecuador chose microcomputers for use in processing their national census. The local Alpha Micro representatives subsequently provided extensive on-site training and actually assisted the Ecuadorians in developing software to process their census.

In Indonesia Osborne microcomputers are being used to enter data from a blindness intervention survey. A malfunctioning machine was quickly repaired by the local Osborne representative, thus saving the time to send it back to the United States for service. The repair amounted to replacing a faulty fuse at a cost of $80; however, in many cases such as this, time justifies expense.

The lack of local representation should not rule out the use of microcomputers. It simply means that issues such as maintenance, training, and support will have to be dealt with in other ways.

## 8.3 Procurement

A lack of knowledge of departmental or national procurement policy can be disastrous to obtaining a microcomputer system in a timely manner. There may be rules governing monetary amounts and the procedures they require, preference to certain manufacturers, bans on importing from particular countries, or the need for extensive justification.

In the United States an attempt is made to keep federal government procurements under $10,000 in order to bypass a competitive bidding process that often results in months or years to obtain equipment. It is common knowledge that many offices procure systems incrementally in order to avoid the lengthy competitive process.

The fault in the United States as well as in many other countries, is one of treating microcomputers like expensive mainframe computers instead of like desk calculators and typewriters which much more closely match their cost.

It may be helpful to talk to other offices which have successfully procured microcomputer equipment in order to gain insight into procurement procedure.

## 8.4 Import Restrictions

Importing a microcomputer can involve problems in customs. These problems range from delays to excessive duties to actual confiscation of equipment.

Larry Brilliant, of the Univeristy of Michigan, gives some advice he gleaned while working on a blindness survey in Nepal: "I would

encourage you to inquire carefully about customs regulations concerning computers, especially concerning CRT's. A major concern in Kathmandu was that we were trying to import a television into the kingdom; it took a good deal of explanation to convince the authorities that the CRT for the Apple could not decode a regular television signal."(2)

Delays due to customs clearance are not uncommon. Dr. Brilliant reports that once the Apple arrived in Kathmandu it was held in the customs warehouse at the airport for 10 days until they managed to obtain approval to bring it into the country. Delays of up to 6 weeks were reported by users in Mauritania, Jamaica, Egypt, Bangladesh, Tunisia, and Australia.

High technology items often carry heavy import duties. In Pakistan, computers are assessed import taxes of up to 60% of their cost.(3) Import duties of 30% were reported in Egypt and Bermuda. Users in Brunei and Australia quoted lower, but still somewhat excessive, import duties.

Being informed is the best way to cope with customs problems. If one understands the potential for such problems, he can look for solutions. For example, hand-carrying a system may result in higher excess baggage cost, but significantly lower import duties and shorter delays.

## 8.5 Training and User Support

Training and user support in developing countries are often inadequate. It may be that there is no person knowledgeable enough to provide either. This really places an enormous burden on the new users and can result in complete and utter frustration. This was precisely the case reported by Tom Eighmy in Morocco when he and his colleagues attempted to use an Apple II.

There are several ways to provide the necessary training and support. At quite a significant cost, the United Nations places a resident advisor in each of its microcomputer sites in order to be a constant source of guidance and information. They admit that the advisor cannot impart sufficient information during his lengthy stay to assure a successful continuation after his departure.

The U.S. Department of Agriculture has relied on periodic short-term visits to its remote sensing project sites. Unfortunately it is often several months before someone can arrive to give assistance because of staff size and budget. In between these visits, the microcomputer users often become frustrated with software they do not understand or problems they cannot seem to remedy.

Training can be provided outside the country if no local source is available. The cost is generally so prohibitive that only a few people can be sent. Several universities in the United States, among them the University of Pennsylvania and the University of Connecticut, have designed programs specifically for foreign

participants that introduce them to microcomputer technology. The ISPC Training Program offers several microcomputer courses in its Computer Data Systems curriculum.

Sandra Bertoli has had extensive experience in developing countries. She recently proposed setting up regional support centers which would offer training to users in their languages. Training would be aimed at managers, computer users, programmers, and service technicians. She sees this approach as filling the gap between sending a few developing country representatives to a (perhaps) inappropriate training program far from home at a great cost, and supplying short-term consultants to provide on-site training through quick ad hoc courses.(4)

Users in all countries are beginning to demand training tools that go beyond reading manuals. As a result, effective tutorials are beginning to appear. These range from a series of video tapes, known as "The Powersharing Series,"(5) which introduces the user to microcomputers in general, to self-taught courses aimed at specific systems, such as the IBM Personal Computer.

Support goes beyond training to encompass the myriad of questions the microcomputer user will ask as he attempts to do useful work with his new tool. Local support, no matter how good, will in some cases prove inadequate. Inquiries to a foreign vendor via letter, telegram, or telephone could prove very difficult for the developing country user. If the developing country user does not have a permanent advisor at his disposal, he will fare much better if he has a source of inquiry in the country of origin of his equipment whom he can contact for advice and answers to questions. It must be recognized that support to microcomputer users is an ongoing function that continues as long as the machine is in use.

Training and support are critical elements to the success of any microcomputer installation. Without them, the machine will at some point be abandoned and put in the corner to collect dust.

## 8.6 Documentation

Documentation of microcomputer hardware and software is often deficient. Developing country users often face the problem of having to use documentation that is not in their language. In addition, users surveyed complained of bad reproduction quality, poor organization, inadequate index, lack of machine-specificity, scantiness, difficulty in comprehension, omissions, errors, no user tutorials, few examples, and documentation too technical for new users. It is obvious that many companies do not give high priority to documentation.

Users can demand that documentation be improved and, over time, it may get better. They can purchase additional documentation from people whose sole livelihood is to improve the documentation of other companies. Or they can make adequate documentation an important selection criterion when choosing hardware and software.

## 8.7 Maintenance

Maintenance is the second biggest problem developing country users face, after problems in power supply. Maintenance alternatives are thoroughly discussed in the chapter dealing with microcomputer technology. Where the dealer is not represented locally, the user must either send components out for repair or repair them himself.

An important issue in any maintenance situation is minimizing down-time. The procurement of redundant systems is perhaps the best way to achieve this. Component redundancy, which allows work to continue even though one complete system is inoperable, is incorporated into most United Nations projects. In addition, or as a compromise, having a complete supply of replacement boards and chips can greatly assist maintenance efforts.

Introduction of a single system into a developing country should be discouraged. An example of the problems this creates is a new Motorola 68000-based Cromemco obtained by the United Nations for a water project in Bermuda. The machine is sitting idle and partially dismantled because it is the only one on the island and noone knows how to repair it.

Hopefully, increasing reliability and a decreasing number of components will lessen the need for maintenance. However, when it occurs, the user should be ready to deal with it in the most efficacious manner.

## 8.8 Warranties

Warranties and software end user agreements can be misleading. They may, in effect, give the user very little recourse if problems arise. The situation is complicated by variations in legal systems among different countries.

If there is any doubt about what protection a warranty or end user agreement offers the user, the questions should be aired with the dealer prior to obtaining the equipment. It should be made clear whether the warranty is from day of shipment or day of delivery, the latter being preferrable because of possible delays in actually receiving the equipment. A 90-day warranty on hardware is standard, although some companies offer extensions to this. The warranty may be voided by various conditions, such as allowing an unauthorized agent to modify a board.

Legal protection only becomes important when a problem arises. The user should make sure he can foresee the outcome before the occasion presents itself.

## 8.9 Environment

Although microcomputers are reputed to make few environmental demands, their care should not be ignored. Excessive dust, moisture, and temperature will eventually prove to be seriously detrimental.

Michael Strong of the University of Pennsylvania participated in a project in Mali which used three IBM Personal Computers. His observation was the following: "Judging by the dust which had accumulated inside the computers between February and December, they should probably be thoroughly cleaned once every 6 months. This is a fairly simple job: unplug all of the components, open the main computer box, and carefully clean wherever dust can settle using the vacuum cleaner and a soft brush."(6)

Internal heat, as well as excessive external heat, can cause a microcomputer to malfunction. Air conditioning may be a necessity if the environment is subject to extremes. The island of Niue in the South Pacific reported that their Apple II broke down mainly as a result of inappropriate storage--open to sea wind, coral dust, and mosquito coil fumes. A user in Indonesia, who reported fungus growing on the boards of his microcomputer because of excessive humidity, solved the problem with air conditioning.

The user should consider providing a clean room with adequate protection against environmental extremes if he expects the best performance from his equipment. Environmental extremes can also be detrimental to floppy disks.

8.10 Power Supply

Unreliable electrical power is the greatest problem facing microcomputer users in developing countries. Electrical problems include spikes (or transients), voltage impulses that are very brief and very large; voltage drops and surges, similar to spikes but longer in duration and lower in peak voltage; and noise interference, unwanted electrical signals caused by anything from static electricity to lightening.(7) Any one of these or several in combination can be fatal to a microcomputer operation. Users in most developing countries, as well as some developed countries, mentioned numerous problems related to unreliable power.

A variety of products are available for isolating and measuring power problems, as well as for protecting power lines. The United Nations has experimented with the use of portable power line monitors for measurement and almost all types of power line conditioners for improving local public power supplies. Apple users in Bangladesh and in countries using the RAPID demographic projections package have met with limited success in using an inexpensive product called Apple Juice to provide power conditioning and back-up power supply. North Star users in Jamaica reported a dramatic improvement in system performance when they installed a voltage stabilizer. USDA recently recommended the use of an Elgar AC line conditioner (at a cost of $3000) for the North Star system it supplied to Sierra Leone.

The best solution to power problems is an Uninterruptable Power Supply (UPS). These can be quite expensive, perhaps equalling the cost of the microcomputer system. Furthermore, certain brands of UPS have problems, such as inability to work with a hard disk system, batteries that do not recharge, and cycle sensitivity. If

one is going to pay a high price for a UPS, it would be wise to attempt to verify its potential effectiveness by identifying another user or, better yet, actually testing it in the environment in which it is to be used or a simulation of that environment. (Elgar markets a product used by the United Nations for power simulation.)

The power requirements that a microcomputer system will place on a UPS can be computed by multiplying the total amperage required by the microcomputer by the line voltage. For example, if the microcomputer. including floppy and Winchester disk drives, a printer, and a CRT, requires 20 amps and the line voltage is 120Vac, the system requirements are 2400VA (or 2.4kVA). This value should be multiplied by a factor if 1.5 to insure that the power requirements can be met by the system selected. In this example, the UPS should be rated at 3.6kVA or higher.

In addition to the inconvenience caused by power line problems, they can be detrimental to both hardware and recording media, such as floppy disks. It pays to take steps to avoid these problems.

## 8.11 Voltage Incompatibility

Many microcomputers are designed to run only using 110 volts. The power in many countries around the world is actually 220 volts. The ideal situation, of course, is to select a microcomputer that is manufactured for the appropriate voltage, such as the EurApple version of the Apple microcomputer, which runs on 220 volts.

Michael Strong, of the University of Pennsylvania, faced the problem of voltage incompatibility when he introduced three IBM Personal Computers (110 V.) in Mali (220 V.). He successfully combined an automobile battery, a battery charger, and a 12 volt DC (direct current) to 120 volt AC (alternating current) inverter to modify the power appropriately. His experience proves that voltage difference can be overcome.

## 8.12 Video Protocol

Often users would like to use conventional television sets as monitors for their microcomputers. A potential problem exists in trying to use European-made televisions utilizing a PALB video protocol with US-made microcomputers which expect a different video protocol. The solution is to assure that the video protocol is compatible before buying a television set for this use.

## 8.13 Arithmetic Accuracy

Accuracy of results on microcomputers can be a problem if software designers do not give it proper attention. Microprocessors are still not in the super number-cruncher class. The majority of microcomputers do not offer floating point hardware. The problem lies with the finite length of the accumulator in which the computer does arithmetic. Suppose, as an example, a microcomputer with an accumulator capable of holding 4 decimal digits multiplies

.6131 by .8432. Instead of the exact answer, .51696592, the computer will calculate .5169 or .5170 if the computer rounds the last digit.(8)

If 8-digit rather than 4-digit precision is needed, the calculation would have to be performed in two parts, with the provision for a carry. There are space and time penalties to be paid for this greater precision.

Some software developers have provided this extended degree of precision on 8-bit microcomputers. David Lingwood, of Action-Research Northwest, reports that recent tests done at the University of Michigan showed accuracy in calculating correlations using his AIDA statistical package for the Apple II to be better than the accuracy of OSIRIS or MIDAS packages running on the (large mainframe) Amdahl 470! He attributes this to the use of "provisional means" algorithms for sums and cross-products, rather than the familiar "machine calculation" formulae.(9)

The user concerned with accuracy should ask questions about precision and how it is obtained, as well as performing some actual benchmarks to verify his findings if at all possible. There is nothing worse than experiencing arithmetic errors for which there is no solution within the means of the user.

## 8.14 Character Sets

Certain languages have special characters not found in the English language, or even employ character sets which are totally different. Microcomputers are generally produced to provide English-language capability and are subsequently modified to handle other languages.

It is important to inquire into the capability to at least print the necessary character set if the user is not English-speaking. A consultant to the World Bank reported using an Arapple, an Apple II+ with Arabic capability. A United Nations resident advisor expressed difficulty in adapting a Texas Instruments printer to display French characters for use on an Altos microcomputer in Mauritania. A recent article in BYTE Magazine described recoding an Epson printer on an IBM Personal Computer to handle international characters.

Unfortunately, the use of different character sets must be approached on an *ad hoc* basis in general. One suggestion is to look to other microcomputer users who need the same character set and see how they have dealt with the problem.

## 8.15 Control of Operations

If microcomputers are employed in a distributed processing environment, there is the potential for problems in controlling operations. For example, if computer-assisted editing is performed by a group of data entry operators at remote sites, care must be taken to assure that they resolve problems in the same way. It is

often difficult enough to enforce standard procedures on a single mainframe doing batch processing. One can see that the introduction of multiple stations which deal with data interactively poses a great responsibility for controlling operations.

Use of special forms and carefully designed diskette libraries can assist in the necessary control. It will be necessary to convince individual employees who deal with data of their importance to the network which generates the final product.

Another aspect of control is the degree of compatibility among systems running on one microcomputer or on several microcomputers. Users must give careful thought to details such as the necessity to transfer files among operating systems or from one brand of hardware to another. This type of problem can be anticipated with proper systems integration and by asking the right questions when acquiring additional systems.

8.16 Misuse of Information

The decentralized information processing capacity represented by microcomputer technology allows users to go beyond the capability or quality of data. There is a possibility for misuse of information.(10)

Microcomputers cannot compensate for bad data. The user must take care to avoid trying to disguise deficient data by clever use of graphics or other capabilities offered by microcomputers. The fundamentals of data preparation must be carefully upheld.

8.17 Incompatible Equipment

The *ad hoc* procurement of microcomputers can result in incompatible equipment. If the equipment is to be used for totally unrelated applications, this is not a problem. However, in most instances, it would be nice to have the possibility of communicating among microcomputers.

This is exactly the case that occurred at the Government Administration Office in Bermuda. Successive procurements resulted in obtaining 4 Apples, an NCR 2950, and a Cromemco, in addition to the IBM System 38 mainframe. The degree of incompatibility among these systems has caused them to choose the CP/M operating system as a means for promoting compatibility among future systems.

It takes a conscientious effort to plan for compatibility. It may even mean sacrificing the latest technological innovations or the fastest speed in order to maintain compatibility. Countries will have to assess the importance of compatibility when determining their microcomputer policies and acquisition plans.

# FOOTNOTES

1 John J. Bennett, "The Use of Microcomputers in Farm Management Surveys" (MSU Conference, May 1982), p. 21.

2 Lawrence B. Brilliant, letter to Robert Bair (April 22, 1982), p. 3.

3 David Kline, "The Micro Comes to Pakistan," Datamation (August 1982), p. 90.

4 Sandra Bertoli and John E. Lamb, "Proposal to Design a Project for the Establishment of a Regional Support Center in the Mid-east for Microcomputers in Development" (August 1982), p. 15.

5 The Powersharing Series, (Hillsdale, New York: Martha Stewart Communications, Inc.) cited by Chip Mann, "Should We Throw the Man an Apple?" (MSU Conference, May 1982), p. 4.

6 Michael Strong, "Mission Report to Sahel Institute - USED" (January 19, 1983), p. 7.

7 Amy Smith, "Power Line Perils," Business Computer Systems (September 1972), p. 122.

8 "The Microprocessor Grows Up," EDP Auditor (Winter 1980), p. 34.

9 David A. Lingwood, reaction to ISPC Initial Thoughts and Findings paper (May 28, 1982), p. 4.

10 "Microcomputers and Agriculture Management in Developing Countries: Workshop Proceedings" (USDA, June 1982), p. 14.

# CHAPTER 9: CRITERIA FOR MICROCOMPUTER SELECTION

Selecting a microcomputer today is no easy task. There are literally hundreds of systems to choose from, each one offering its own particular hardware or software benefits. The matter is further complicated for some developing countries by their remoteness or special environmental constraints.

This chapter will offer a rational approach to the selection process that should give the prospective user the assurance that he made an educated selection, given his particular requirements at that point in time. The latter phrase is especially important because the constant introduction of new products and changes in technology make it impossible to be forever content. This rapid change causes many users or potential users to consider putting off a decision for fear that something better is imminent, that the ultimate system is just around the corner. In fact, any system will quickly become outdated, but it is better to begin somewhere than to sit back and watch.

## 9.1 Intended Use

The selection process must begin with decisions as to how the machine will be used. Possible uses for microcomputers, as well as ideas on introducing microcomputers into the office, are discussed elsewhere in this document. Therefore, this chapter presunposes the identification of specific uses for the microcomputer.

Prospective users should be wary of going into this decisionmaking process with a preconceived idea of what they wish tc buy, especially if their notion is the latest product to hit the market. Just because a microcomputer utilizes the most current technology does not mean there will not be serious problems. For example, when the IBM Personal Computer was announced, there was virtually no software available for the 16-bit machine.(1)

The specific uses to which the machine will be put imply a set of requirements for hardware and software. These should be ranked in priority order. It may be imperative to have a multiuser system, a COBOL compiler, or the ability to run a particular software package. These are the requirements that will be used to eliminate most of the numerous contenders.

## 9.2 Software Options

Careful thought needs to be given to the use of packaged software wherever possible. It may not completely meet the requirements, but the cost differential makes it imperative to at least consider the use of packages. With commercial program packages, development costs have already been spread over a number of users.

Commercial packages have three further advantages. First, most of the errors in the programs have been found and corrected. Second, such packages are constantly updated and improved. The cost of an

update is typically only a fraction of the initial purchase price. In some cases, however, it is necessary to buy the package again in order to have access to the modifications. Third, buying packaged software allows one to rely on the expertise of others without having to become an expert himself.(2)

Particular software needs should be an extremely important factor in the choice of a microcomputer system. There are some basic questions to be answered for any particular piece of software, whether it be an operating system or an applications package. They include:

-- How many other users of the package are there?
-- How old is the current version of the package?
-- For what hardware and operating system was the package originally written?
-- Does the package require the presence of other packages?
-- How is maintenance provided for the package?
-- What documentation is provided with the package?
-- Is training in the use of the package available?
-- Does the vendor supply package tailoring?
-- Is there an active users group for the package?(3)

## 9.3 Evaluation

### 9.3.1 Evaluation Form

A form should be developed for use in evaluating microcomputer systems. It should include data on all factors which contribute to meeting the requirements listed. The following list of points can serve as a beginning to develop such a form:

- Hardware
  - CPU chip
  - Memory capacity (maximum KB)
  - Maximum floppy disk drives
  - Disk size (5-1/4" or 8")
  - Disk capacity (maximum KB)
  - Inclusion of hard disk
    - If no, hard disks that are compatible
  - Color capability
  - Screen color
  - Screen format (character per line by number of lines)
  - Graphics resolution (number of pixels horizontal by vertical)
  - Inclusion of monitor
    - If no, monitors that are compatible
  - Inclusion of printer
    - If no, printers that are compatible
  - Keyboard features
  - Multiuser capability
  - Ergonomic features
  - Peripheral capacity (number and kino of ports)
  - Current and frequency requirements
  - Voltage surge protection

Upgrade potential
Software
Operating system(s)
Languages included
Capable of running certain languages (for example, COBOL)
Packaged software included
Capable of running certain packages (for example, Visi-Calc)
Purchase price (range)
Maintenance
Local representative
Expected turnaround if sent back to manufacturer
Documentation
Understandable
In host-country language
Indexed

Particular areas may need to be elaborated to include special requirements, such as the speed and quality of the printer. Or perhaps, if the system is to be custom configured, a form should be prepared for each component (printer, monitor, hard disk, etc.). This becomes a much bigger task.

### 9.3.2 Initial System Review

Deciding which systems to evaluate requires considerable knowledge of what is on the market. Publications such as BYTE Magazine are very useful in providing vendor identification. Once prospective systems have been identified, obtaining the necessary information for each of them is not an easy task. Some of it is available in trade magazines. However, the best approach is talking to a local representative or writing directly to the vendor.

After the information has been compiled, it will be obvious that some systems could possibly meet the needs of the office, whereas others obviously fall short. For those systems which seem to be possibilities, considerable effort still needs to be expended. The first step is finding out whether, how, and from whom the system can be obtained for a particular country. (Some vendors do not market outside the country of manufacture and therefore do not make systems compatible with multiple power requirements.) Mark Garetz of CompuPro, Inc., offers two pieces of advice:

-- If at all possible, avoid buying products directly from manufacturers. Buy instead from a local dealer or systems house. Generally manufacturers cannot provide adequate support and the "hand-holding" usually necessary when bringing up a system.

-- If there is no local dealer, look around for an independent consultant who could be responsible for system installation and support.(4)

In looking for prospective vendors, one should make every effort to identify persons who will be responsible for both hardware and software and will assure the two are properly integrated.

9.3.3 In-Depth Review

The next step is a more in-depth review of hardware, software, and vendors. Hopefully, the list of remaining contenders will include no more than 10 systems.

9.3.3.1 Integration into Current Computing Environment

Further evaluation of the hardware should include how it will fit into the current computing environment, upgrade capability, warranties, more attention to documentation, whether or not any necessary customization is feasible, and possibly benchmarking.

9.3.3.2 Communications Potential

If transfer of data or programs between an existing computer and the microcomputer is desired, it would be ideal to try it if at all possible. For example, if the communication were to be accomplished via floppy disk and one could be obtained, the user could assess the compatibility. If, in the more likely case, communication could not be simulated, a very detailed discussion of how it would be achieved should take place.

9.3.3.3 Upgrade Potential

Mark Garetz lists some questions to ask about upgrade potential:

-- (If not already in the system), can a 16-bit CPU be added at a later date?
-- Can more users be added?
-- More mass storage?
-- More memory?(5)

Questions such as these are important because the intended use of the machine may change over time.

9.3.3.4 Warranties

Garetz provides some questions on warranties offered:

-- Does the manufacturer or dealer offer a substantial warranty (that begins only when the machine has been successfully installed)?
-- Is a maintenance contract available?
-- Is there a one-day (or same-day) board replacement program?(6)

When a computer goes down, it can be expensive.

9.3.3.5 Documentation

Garetz also advises making sure the system is well documented. One should be able to obtain manuals for all the parts of the system. They may never be needed, but if the dealer that sold the system goes out of business and the system ever goes down, the technician that fixes it will be grateful. The user's manual should be adequately written so that he does not need to call the dealer every time a question arises.(7)

9.3.3.6 Customization

If the system requires any customization, even the addition of a printer, one should try to establish that the particular integration has been accomplished successfully by someone else. This becomes more and more complex as custom components are added instead of standard system components. It is often the mix of components that creates incompatibility, not any one component in particular. For this reason, it is best to stay with systems which have been integrated by the vendor, if at all possible.

9.3.3.7 Benchmarking

If speed is an important factor, as it probably is for most statistical offices, benchmark programs can be used to measure it. Benchmark programs are "typical" programs written by the user to test the operating speed of the processor (and associated peripherals) being considered in actual cases.(8) For example, programs to generate prime numbers or pseudo-random numbers are good candidates. If the program can be written in the same language from the same source (for example, MicroSoft BASIC or MBP COBOL), the validity of the benchmark will be greater, as software can greatly affect performance speed.

If one does not have access to all the microcomputers under consideration, he can choose to rely on published benchmarks in periodicals such as BYTE Magazine. These may not cover all of the machines in question; however, more and more is being written to compare systems as competition becomes stiffer.

9.3.3.8 Software Evaluation

Further software evaluation includes assuring compatibility and learning as much about the software as possible. Certain pieces of software run only under a particular operating system or require a particular type of peripheral (such as a serial, as opposed to a parallel, printer). The best way to judge compatibility of software is to see it demonstrated on the machine. Unfortunately, this is often not possible.

Some software must be adapted to the particular system. One should make sure the vendor is willing to do this or that the user has in-house capability to achieve the adaptation.

Usually manuals can be ordered independent of the software at a small cost. In most instances, the money will be applied to the purchase price of the package. Studying software manuals is a good way to learn the extent of the capabilities provided and the degree to which the software is user-friendly.

9.3.3.9 Vendor Evaluation

Evaluation of vendors is of particular importance, since the vendor will probably be the first place one turns for questions or problems. The vendor is usually responsible for support including:

-- Assistance in selecting systems hardware, software, and components.
-- Prompt delivery of ordered items.
-- Post-sales training.
-- Hardware maintenance programs.
-- Repair services.
-- Supplying the bits and pieces of information which inevitably are missing.(9)

If no dependable and capable support is locally available, then perhaps greater consideration should be given to a system for which local support is available.

In evaluating a vendor, the following points should be considered:

-- Does the vendor know his business thoroughly?
-- Does the vendor sell and service most of the equipment you will need?
-- Is the vendor motivated to do business with you?
-- Does the vendor repair what he sells, or does he send equipment out?
-- Does the vendor maintain an adequate stock of replacement parts and components?
-- Can the vendor supply or recommend service technicians who will make on-site visits?
-- Does the vendor supply spare modules on a loan or rental basis?
-- What is the vendor's track record? Is he likely to be in business for the life of the system?(10)

The vendor himself will be the best source of information. If he can provide references who can be contacted, they can supply independent appraisals of the vendor's performance.

9.4 Summing Up

The prospective user should have a good feeling for what systems and software will be satisfactory once he has gone through this evaluation process. It may be that there is no ideal system, that every system has certain drawbacks.

It would probably be useful to tally a score for each system based on the evaluation criteria. A 1/0 count would suffice for yes/no

responses. A scale of 1 to 5 could be used for questions that measured to what degree something was true. In accord with the original priorities set down, responses to certain criteria should be weighted to reflect their priority. These might include issues such as service, training, documentation, and cost.

Once this exercise has been completed, the user will have the assurance that his choice was based on a thorough and methodical evaluation. He will have evaluated the complete picture -- hardware, software, vendors.

The irony is that this type of evaluation process can be quite costly because of the time and effort involved, perhaps many times the cost of an individual system. However, if the office is considering multiple systems or incorporating this one into a long-range plan, living with a mistake can be far more costly in the long run. Thorough evaluation is worth its price.

## FOOTNOTES

1 Bob Johnson, "Don't Let Users Buy Their Own Micros," <u>Computerworld</u> (November 22, 1982), p. 16.

2 Phillip I. Good, "Software Makes the System," <u>Computer Decisions</u> (February 1981), p. 58.

3 "Questions Before Buying," <u>Computerworld</u> (January 25, 1982), Speical Report p. 37.

4 Mark Garetz, "Tips on Buying a Micro-Based Business System," <u>Computerworld</u> (November 15, 1982), p. 24.

5 <u>Ibid</u>.

6 <u>Ibid</u>.

7 <u>Ibid</u>.

8 Rodnay Zaks, <u>From Chips to Systems</u> (Berkeley: Sybex, 1981), p. 264.

9 Jeffrey Stone, "<u>Microcomputer Selection Study</u>" (World Bank, July 16, 1981), p.10.

10 <u>Ibid</u>., p. 11.

# CHAPTER 10: REVIEW OF MICROCOMPUTER SOFTWARE

## 10.1 An Overview of Software Selection

Computers are used to insure that data are processed more accurately (by removing elements of human error) and more quickly (by substituting fast machine controlled operations for relatively slow human activities). Achieving either of these goals is largely dependent upon the computer software that is used to accomplish the processing. Software may either be purchased as a package or developed to meet a particular need.

The first step of software selection is the determination of the work the computer will be required to perform. Once performance requirements are known, attempts can be made to identify sources of packaged software capable of meeting these requirements. If satisfactory packaged software is not available, plans must be made for the development of custom software or the modification of available packaged software. The advantages of packaged software are considerable, since custom software is costly, and, without strict controls and testing procedures, is error-prone. Packaged software that has been widely marketed and accepted, on the other hand, can usually be relied upon to perform to specifications, and it is an inexpensive way to capitalize on the considerable technical expertise of an established software firm. One of the strengths of the microcomputer is the abundance of useful packaged software that has been developed for it.

For some tasks, packaged software is the only reasonable alternative. Operating system software and high-level language translators involve enormous investments of technical skill and time and must be leased or purchased as packaged software. Less obviously, but no less importantly, functions such as file sorting, text editing, word processing, and communications between computer systems ought to be supported by packages. In-house development of software for such tasks is unnecessary and far too expensive to be justified in any but the most unusual circumstance.

In application areas other than word processing, communications, or other necessary system utilities, the choice between packaged software and custom software development is more difficult. Although use of packaged software is to be preferred to the development of custom software, adequate packaged software may not be available. The use of packaged software almost always requires compromises in the way data are processed. Rarely does a package do things in exactly the manner desired. Further, those familiar with mainframe computer processing will find that many of the restrictions imposed by microcomputer software packages are sufficiently confining to urge the development of alternative software.

NSO statisticians accustomed to the statistical software available for mainframe computers will find packaged microcomputer software for statistical computing to be more limited in the number of cases

or observations that may be dealt with, in the number of variables that may be examined at one time, and in the range of statistical functions that are supported. On the other hand, they may find that the interactive nature of much statistical software makes it easier for them to examine and manipulate small data files. Statisticians eager to work directly with the computer will find that they can begin to use one of the statistical packages available for microcomputers in a relatively short period of time.

Most available packaged statistical software will aid in the production of frequency distributions and crosstabulations (when these tabulations are based upon frequencies and not sums). Support for calculations involving weighted data or special handling of missing values is more difficult to find, however. True tabulation software, allowing the production of complex crosstabulations involving sums or continuous variables, is uncommon, and, until it is available, it may be necessary to develop custom programs to generate tables.

The question that must be faced, in cases where software with more limited capabilities than those desired is available, is whether or not the compromise that use of a package would require is acceptable or practicable. Sometimes the design of a processing system can be modified to adapt to limitations imposed by packaged software; in other cases, it cannot. As an example, data base software such as dBASE II and Condor makes the task of collecting and editing files of data a straightforward one without custom software development. Both packages, however, impose restrictions that may seem unreasonable for some applications. dBASE II allows no more than 32 variables per record, no more than one record description per file, and a maximum of 65,536 records per file. Condor Series 20 allows 127 fields per record but only 32,767 records per file. Use of either of these two packages in projects that involve files of data that do not fit within the limitations imposed by the packages will require careful planning and management.

In many statistical processing jobs undertaken by NSO's on microcomputers, there will be tasks that cannot be satisfactorily accomplished without modification of available packaged software or the development of custom software. Since source code for packaged software is rarely available, modification of packaged software will seldom be an option and custom program development will be necessary. In either case, however, the computer must provide an environment in which program development can take place.

A high-level language compiler or interpreter must be selected if program development is planned. BASIC interpreters are standard software for most microcomputers, and they will prove to be useful for a wide range of routine activities. In cases where a completely compatible BASIC compiler is also available, BASIC may offer a particularly attractive program development environment combining the convenience of an interpreter in program coding and debugging with the speed of a true compiler at the time of production processing. For large processing tasks where program

size urges a modular design or speed of execution is important, however, the use of other programming languages will be preferred.

Microcomputer compilers and interpreters vary enormously in quality, power, allowed size of programs, size of internal data storage, speed of compilation, speed of execution, and compactness of generated code. In languages for which there are established standards, different compilers may implement different levels of the standard. Because many microcomputer compilers are new, they are likely to have problems, and it is advisable to talk with at least one well-informed user before making a decision. Poorly documented and poorly tested compilers are a plague to software developers; they can play havoc with the most carefully planned development schedule. The President of SPSS, Norman Nie, has attributed the delay in delivery of a microcomputer version of SPSS for the IBM PC to the encounter of "at least one undocumented compiler error for every hundred lines of code."(1) If the use of a particular language is judged essential to the success of the project targeted for a microcomputer, the selection of a compiler may dictate the selection of both operating system software and system hardware.

The selection of an operating system for the microcomputer will be strongly influenced by decisions that have already been made about application and compiler software since these packages will be operating system specific. For example, if work planned for the microcomputer is to be accomplished by software that is available for the UCSD p-System alone, then that will be the operating system to select. If the selected application software is spread across several operating systems, there may still be the possibility of using all of it by finding a system that offers more than one operating system. Many microcomputer vendors offer a choice of operating systems for their product. For example, CP/M-86, MS-DOS, and the UCSD p-System are available for the the IBM PC, and, with the addition of a Z80 microprocessor card, CP/M is available also. It may be not only feasible but desirable to purchase more than one operating system in order to increase the flexibility of the microcomputer and to support the full range of application software and compilers that have been selected.

The availability of several different operating systems is not an unqualified advantage, however. If more than one operating system is selected, there will be pressure to purchase a relatively complete complement of software for each operating system. If more than one operating system is used in the processing of a single file of data, there is likely to be a need for setting up procedures by which a file maintained under one operating system may be converted to a file that can be used by the other operating system. (It is uncommon for different operating systems to share a common file format.) The use of more than one operating system also introduces the need for training in the use of software that may perform similar operations using an entirely different set of commands. The opportunity for confusion and accidental errors is considerably increased.

It is strongly advisable to select one of the more common operating systems, because of the amount and quality of software that is available for them. Widely-used and well-documented operating systems encourage competition among independent software developers; this results in better software design and higher quality in available software products. An operating system that offers an exceptionally simple but powerful command structure or that is easy to use because of menu assistance for the user may be attractive, but, if it does not offer support for application software that is needed, it will be of little use.

New software packages appear regularly, making it difficult to decide what to buy and when to buy it. Choosing between the greater power and improved capability promised by newer packages and the reliability of older but well-tested and well-established software packages is difficult. The older operating systems, such as CP/M, Oasis, and the p-System tend to have more mature software that can be expected to be more thoroughly tested and reliable. New systems and new software packages can be expected to have undocumented errors.

General guidelines:

Begin with a plan for the microcomputer's use. Try to identify packaged software that will meet as many processing requirements as possible. If only small computer programs must be developed, BASIC may be satisfactory for any program development needed; for larger programming efforts, other languages such as Pascal, FORTRAN or COBOL should be considered. Consult experienced users in selecting a language interpreter or compiler. Selection of an operating system (and the microcomputer itself, perhaps) may be made on the basis of the requirements of application and/or compiler software. It may be desirable, in some cases, to purchase more than one operating system.

## 10.2 Software for Data Processing(2)

The availability of inexpensive packaged software that simplifies the use of the computer for data processing purposes is one of the most promising aspects of the microcomputer's debut. Some of this software, marketed as data base management or statistical software, makes it feasible for a person with no computer programming experience to plan and carry out relatively complex processing tasks on the microcomputer, sometimes with very little effort. In most cases, however, the ease of use of these packages has been overstated, and a fairly high level of computer literacy as well as skills that have traditionally been classified as programming skills are required for their effective use. Nevertheless, packaged data handling, statistical, and tabulation software can significantly reduce the effort involved in data entry, editing and analysis.

Software packages sold as data base management software offer a set of basic tools for entering and editing data and for producing reports. Within the limitations they impose on number of records

and number of variables, these packages provide a straightforward and simple means of creating and maintaining a computer data file. Some go considerably further than this and offer a more complete command language that adds considerably to the power and flexibility of the system, making it possible to deal with the exceptional or the complex case. Training in the use of these more powerful data handling "languages" may require a substantial investment of time, but the investment is likely to be repaid many times over by the increased amount of processing that can be done.

Statistical software developed for smaller microcomputers may fall short in providing the full range of functions available with mainframe statistical packages and may be much more limited in the number of records or the number of variables that may be handled, but, again, it offers important basic data processing capabilities that are useful to a statistical office. Some of these packages excel in providing support for the user, making it easy to go from data entry to analysis of variance with a minimum of training or effort. Unfortunately, it is these same packages that impose the most stringent limitations on size of data files or number of variables.

Statistical packages offering many data handling capabilities still do not provide the degree of flexibility that is desirable for such important tasks as performing checks on the integrity of data. For all but the smallest and most limited processing jobs, it should not be expected that a statistical package alone will prove sufficient to meet all processing requirements. Plans should be made for coordinating the use of a data base management package and a tabulation package with the use of the statistical package. Speed of processing, software bugs, and arithmetic precision may all prove to be problems as well.

Tabulation software is much more difficult to find than statistical software. Although statistical packages provide support for the generation of frequency distributions or crosstabulations based upon frequency counts, the use of weights or sums in tables is rarely supported. When true table generation capability is provided, it may be possible to create only a single table on one pass through the data. Two packages that might be described as general purpose, tabulation software are ACCESS/80 (available for CP/M) and ACCESS/86 (available for CP/M-86). Both allow the generation of several tables on a single pass through the data file.

The primary obstacle to the successful use of several different software packages, each used for a different function, is incompatible data formats. If a data base management package using its own peculiar record formats is to be used with a statistical package written in Microsoft BASIC and requiring that data be in a different format, a considerable effort will need to be made to move data files between these two packages. It is possible with careful planning, however, to find data base, statistical, and tabulation software that is capable of working with fixed-length, fixed-field, ASCII character records. Under CP/M, for example, it

is possible to examine files created, edited, and copied under dBASE II using SL-Micro and ACCESS/80. Although the fit is not perfect, no custom programming effort is required to pass data between these programs.

Software to generate basic graphical reports such as bar charts, line graphs and pie charts is available. Graphics packages, however, do not have the capability of producing summary statistics and must be used in conjunction with statistical software. Unfortunately, neither statistical nor graphics package designers have done much to facilitate the passing of data, and the use of a graphics package, in most instances, will require rekeying data from a printed report or writing a custom program to prepare appropriately formatted summary data files.

Graphics software is especially sensitive to a change in peripheral equipment; each package is designed to work with a particular CRT device, printer, or pen plotter. Be sure that the software you plan to buy to produce printed bar charts, for example, will work with the dot matrix printer that is to be attached to the intended microcomputer system. Do not expect to be able to substitute equipment that appears to be functionally equivalent.

Application software development tends to cluster around the more popular operating systems. The majority of software packages available at the time of this report are available for 8-bit microcomputer systems such as the Apple II, the TRS-80, and CP/M and UCSD p-System based systems. Application software for 16-bit microcomputers has centered around MS-DOS and CP/M-86. In many cases, packages available for the newer 16-bit systems are mere adaptations of older 8-bit software that have retained many of the limitations imposed by the more restrictive 8-bit environment. It is reasonable to expect that similar packages exploiting the increased addressing capabilities of the 16-bit systems will be available soon, but not much is available in early 1983.

In situations where data entry with editing is required, specialized data entry software is available. Some programming effort may be required to develop a customized data entry format, but this software is probably entirely sufficient to meet data entry needs. The availability of this software makes the microcomputer a flexible data entry system.

General guidelines:

Know your data processing requirements in advance. While useful data handling and statistical evaluation software packages are available, all place limits on such things as the number of records that can be processed, the number of variables or fields within a record that can be handled, the width of a field, the largest number that can be represented and so on. Expect to work with relatively small data files if packaged software is used. Do not expect a single package to meet all your data processing needs. Plan for passing data files between packages and select packages on

the basis of their ability to work together with other useful software.

### 10.2.1 Data Base Software

-- With the exception of MDBS, microcomputer data base management software packages are not designed in the same manner as mainframe host language data base systems. Microcomputer packages are self-contained and much simpler to use. While they may be remarkably powerful and useful, the may provide less flexibility than mainframe packages.

-- It is extremely helpful if data base management software can easily accept or produce data files in a standard format. This feature will make the package much more useful and flexible, since data from other sources may be easily entered into a data base, and data from the data base may be easily accessed by a custom program or another piece of packaged software. For example, it should be possible to take a sequential, fixed-length, fixed-field data file processed by a COBOL or FORTRAN program and load it directly into a data base with a single command.

-- Some useful articles on selecting a microcomputer data base management package are (1) "Which DBMS is Right for You?" by Harvey M. Weiss in _Mini-Micro Systems_, Vol. XIV, No. 10 (10/81), pp. 157ff., (2) "Database Software Packages for Micros" by Patrick Kenealy in _Mini-Micro Systems_, Vol. XV, No. 9 (9/82), pp. 193ff., and (3) "Buyer's Guide to Database Management Systems" in _Desktop Computing_, Vol. 3, No. 3 (3/83), pp. 42ff.

Name: _Condor III (Series 20)_.
Type: Data base management software.
Manufacturer:
Condor Computer Corporation
P. O. Box 8318
Ann Arbor, MI 48107
(313) 769-3988.
Price: $650.
Operating System: CP/M, MP/M, MS-DOS, CP/M-86, PC-DOS, TurboDOS.
Minimum System Requirements: 64KB RAM (80KB for the IBM-PC), CRT terminal with cursor addressing, screen erase and line wrap, two floppy disk drives with 300KB of storage, and a printer with form feed.
Factors for Consideration:
- -- Maximum number of records per file is 32,767.
- -- Will allow 2 files to be in use at the same time.
- -- Maximum record size is 1024 bytes.
- -- Maximum number of fields per record is 127.
- -- Maximum field length is 127 bytes for alphabetic data or 10 digits for numeric data.

-- No support for heirarchical or network structured files.
-- Includes a powerful command language with some menu-driven formats and accepts command programs that have been prepared using its own or other text editors.
-- For a review of Condor III, see Jack L. Abbott, "Condor Series 20 DBMS," BYTE, Vol. 7, No. 12 (12/82), pp. 404ff.

Name: dBASE II.
Type: Data base management software.
Manufacturer:
Ashton-Tate
9929 West Jefferson Blvd.
Culver City, CA 90230
(213) 204-5570.
Price: $700.
Source Language: 8080 assembler code.
Operating System: CP/M 2.X, CP/M-86, MS-DOS.
Minimum System Requirements: 48KB RAM.
Documentation: Includes an index and tutorial.
Factors for Consideration:
-- Maximum number of records per file is 65,535.
-- Will allow 2 files to be on-line at the same time.
-- Maximum record length is 1000 bytes.
-- Maximum number of fields per record is 32.
-- Maximum field length is 255 bytes.
-- No support for heirarchical or network structured files.
-- Includes a powerful command language and accepts command programs that have been prepared using its own or other text editors.
-- For a review of dBASE II, see Jack L. Abbott, "Database Management with Ashton-Tate's dBASE II", BYTE Magazine, Vol. 7, No. 7 (7/82), pp. 412ff.

Name: DB-Master (Version 3).
Type: Data base management software.
Manufacturer:
Stoneware, Inc.
50 Belvedere Street
San Rafael, CA 94901
(415) 454-6500.
Price: $229 for the Apple II (a hard disk version is available for $499); $500 for the IBM PC.
Operating System: Apple II, Apple II+, PC-DOS.
Minimum System Requirements: DOS 3.3, one disk drive (2 are recommended; 4 are supported), printer, ROM Applesoft Basic or Language System.

Factors for Consideration:
- -- Maximum number of records is 1 million.
- -- Maximum number of bytes per record is 1020 for the Apple II version, 3000 for the IBM PC version.
- -- Maximum number of fields per record is 100 for the Apple II version, 250 for the IBM PC version.
- -- Maximum number of bytes per field is 1020 for the Apple II version, 3000 for the IBM PC version.
- -- Supports multi-diskette files.
- -- DB Master performs as promised but, at least in its Apple version, it is slow and awkward to use.

Name: InfoStar.
Type: Data base management software.
Manufacturer:
MicroPro International Corporation
1299 4th Street
San Rafael, CA 94901
(415) 457-8990 Telex: 340-388.
Price: $495.
Operating System: CP/M.
Factors for Consideration:
- -- Maximum number of records per file is 65,000.
- -- Maximum number of bytes per record is 65,000.
- -- Maximum number of fields per record is 255.
- -- Maximum number of bytes per field is 255.

Name: FMS-80.
Type: Data base management software.
Manufacturer:
DJR Associates, Inc.
2 Highland Lane
North Tarrytown, NY 10591
(914) 631-6766.
Price: $995.
Operating System: CP/M, MP/M, CDOS (Cromemco), TurboDOS, UNIX.
Factors for Consideration:
- -- Maximum number of records per file is 65,535.
- -- Will allow 19 files to be on-line at the same time.
- -- Maximum number of fields per record is 255.
- -- Maximum number of bytes per field is 255.
- -- For a review of FMS-80, see Jack L. Abbott, "Systems Plus: FMS-80," BYTE Magazine, Vol. 7, No. 10 (7/82), pp. 447ff.

Name: MDBS III.
Type: Data base management software.
Manufacturer:
ISE-USA
85 West Algonquin Road, Suite 400
Arlington Hts., IL 60005
(312) 981-9200.
Price: $2225.
Operating System: CP/M, MP/M, CP/M-86, MP/M-86, UNIX, XENIX, North Star DOS, TRSDOS, Apple DOS, PC-DOS.
Factors for Consideration:
A full implementation of the CODASYL standard. MDBS differs from most other data base packages in that it is a data base management tool for use within any of a number of host languages. (Pascal, COBOL, BASIC, C, FORTRAN, and PL/I interfaces are available.) Unlike the other DBMS packages listed here, use of MDBS requires custom program development. This software is consequently not recommended for those without some knowledge of data base management theory and programming experience.
-- Allows up to 255 record types per data base.
-- Maximum record length is 4 billion bytes.
-- Maximum number of fields per record is 65,535.

Name: MicroRIM.
Type: Data base management software.
Manufacturer:
MicroRIM, Inc.
P. O. Box 585
Bellevue, WA 98009
(206) 453-6017.
Price: $795.
Source Language: FORTRAN.
Operating System: CP/M, MS-DOS, CTOS.
Minimum System Requirements: CP/M: 52KB RAM, 152KB disk storage (2 drives strongly recommended), standard CRT (TTY compatible), standard 80- or 132-column ASCII printer. MS-DOS: 256KB RAM, disk drive, Victor 9000 terminal or IBM PC with monochrome or color graphics monitor.
Factors for Consideration:
-- Maximum number of bytes per record is 1274.
-- Maximum fields per record is 400 for MS-DOS; 127 for CP/M.
-- Number of records is limited by disk capacity.

## 10.2.2 Statistical and Tabulation Software

-- A large number of microcomputer statistical packages are advertised. Some appear to be little more than programs implementing textbook statistical formulae. Further, cost is not a reliable measure of performance. It would be

best to find an individual who has used the package that is of interest in order to verify that those functions deemed critical are available and to check on the package's performance.

-- Much statistical software is new and some is not well-tested. There are occasional reports of serious errors in statistical routines. A certain amount of scepticism about results may be appropriate at the start.

-- A few major mainframe statistical packages are available for larger microcomputer systems, but most microcomputer statistical packages are considerably more modest, especially in their data handling abilities.

-- Many data base management packages offer report capabilities, but few offer the tabulation features that will often be useful in NSO's. There is nothing fully comparable to TPL (Table Producing Language developed by the U. S. Bureau of Labor Statistitics) or CENTS 4 (Census Tabulation System Version 4 developed by the U. S. Bureau of the Census) for microcomputers at the time of this report.

-- The ability to access data files in a standard format, such as a sequential file with fixed-length, fixed-field records produced by a COBOL or FORTRAN program, is an enormous asset. Not all statistical packages allow this, and this is especially true of those written in BASIC.

-- Packages that use binary-coded decimal arithmetic may offer greater accuracy and may accommodate larger values than those that use integer and floating point arithmetic. Limitations on the size of an integer in some 8-bit microcomputer interpreters and compilers has been carried over into statistical software and may present problems when large totals are involved.

Name: A-Stat 79.
Type: Statistical software.
Manufacturer:
Rosen-Grandon Associates
7807 Whittier Street
Tampa, FL 33617
(813) 985-4911.
Price: $175.
Source Language: Applesoft BASIC. A fully compiled version is available also.
Operating System: Apple DOS 3.3.
Minimum System Requirements: 48KB RAM, Apple DOS 3.3, one disk. A printer and more than one disk are recommended.

Factors for Consideration:
-- A-STAT is an implementation of a subset of P-STAT 78. It is designed to be command compatible with P-STAT.
-- Command- rather than menu-driven.
-- Maximum number of variables is 45.
-- Precoded variables are limited to 21 categories.
-- Maximum number of cases is 2600.
-- Editing of data at time of entry is not supported.
-- A review of A-Stat can be found in Infoworld, Vol.4, No. 17 (4/26/82), pp. 35ff.

Name: ABSTAT.
Type: Statistical software.
Manufacturer:
Anderson-Bell
5336 South Crocker Street
Littleton, CO 80120
(303) 794-7509.
Price: $395.
Operating System: CP/M.
Minimum System Requirements: 48KB RAM, 300KB disk storage.
Factors for Consideration:
-- Offers an interface to dBASE II.

Name: ACCESS/80 (and ACCESS/86).
Type: Tabulation software.
Manufacturer:
Friends Software Corporation
Tioga Building, Suite 440
P. O. Box 527
Berkeley, CA 94701-0527
(415) 540-7282 Telex: 172 029 ANS: SPX-SRFL.
Price: $500 for Level II.
Operating System: CP/M, MP/M, CDOS, (CP/M-86 for ACCESS/86).
Minimum System Requirements: 48KB RAM, at least one floppy disk drive, video terminal with 24 line and 80 character display.
Documentation: Documentation includes a tutorial but no index. On-line documentation aids are provided.
Factors for Consideration:
-- Provides a powerful command language that makes table generation relatively easy. Commands may be created using a text editor and submitted in batch mode for processing.
-- Sold in one of three levels. Level I provides basic report generation capability. Level II makes it possible to store and retrieve information using the package. Level III adds updating and indexing capability.
-- Maximum number of records is 65,535.
-- Maximum number of bytes per record is 32,764.
-- Maximum number of characters per field is 255.

-- Approximately 400 variables may be defined.
-- Provides for 16 digits of accuracy.

Name: AIDA (Apple Interactive Data Analysis).
Type: Statistical software.
Manufacturer:
Action-Research Northwest
11442 Marine View Dr., S.W.
Seattle, WA 98146
(206) 241-1645.
Price: $235.
Operating System: Apple II DOS.
Minimum System Requirements: 48KB RAM, one disk drive.
Factors for Consideration:
-- Command oriented.
-- Can support more than 4,000 records under certain circumstances.
-- A review of AIDA can be found in Infoworld, Vol. 5, No. 11 (3/14/83), pp. 50ff.

Name: BMDP.
Type: Statistical software.
Manufacturer:
BMDP Statistical Software
1964 Westwood Boulevard, Suite 202
Lo Angeles, CA 90025
(213) 475-5700 TWX: 910 3436906.
Price: BMDB programs are apparently provided in a manner similar to software for mainframes. There is a first time charge followed by an annual fee for each program used. In the first year, the first 10 programs cost $600 to $1000 with additional programs costing $30 to $50 each. Programs must be renewed in subsequent years at rates from $30 to $50 per program. Rates vary according to the three purchaser classifications, academic, non-profit, and commercial.
Source Language: FORTRAN.
Operating System: STATCAT's UNIX System III
Minimum System Requirements: BMDP software is packaged with the STATCAT system. The complete system costs between $9,985 and $14,925.
Factors for Consideration:
-- BMDP is a mature and well-established mainframe statistical package.

Name: <u>ELF (Econometric Linear Forecasting)</u>.
Type: Statistical software.

Manufacturer:
The Winchendon Group
3907 Lakota Road
P. O. Box 10114
Alexandria, VA 22303
(703) 960-2587.
Price: $200.
Source Language: For the Apple DOS version, Apple BASIC and assembler; for the CP/M version, Pascal.
Operating System: Apple DOS 3.3, CP/M.
Minimum System Requirements: Apple: 48KB RAM, one disk drive, DOS 3.3, Applesoft BASIC or Language System.
Factors for Consideration:
- -- Menu-driven and easy to use.
- -- Includes a superior regression analysis routine.
- -- Lacks some useful data handling capabilities.
- -- Does not provide for missing values.

Name: <u>Interactive Statistical Inquiry System (ISIS)</u>.
Type: Statistical software.
Manufacturer:
Information Systems International
P. O. Box 1725
Concord, NC 28025
(704) 786-2595 Cable: ISISS.
Price: $250.
Source Language: Applesoft BASIC.
Operating System: Apple DOS 3.3.
Minimum System Requirements: Apple II with 48KB RAM and Applesoft ROM, video display, two disk drives, DOS 3.3, 132-column printer.
Factors for Consideration:
- -- Menu-driven software that is very approachable for the first-time or occasional user.
- -- Offers a selection of basic statistical routines including frequencies, crosstabulations, correlation, and multiple regression.
- -- Maximum number of cases is 200.
- -- File format requirements make it difficult to use data not keyed under the ISIS package.
- -- Editing at the time of data entry is not supported.

Name: <u>MICROSTAT (Release 2.0)</u>.
Type: Statistical software.
Manufacturer:
Ecosoft, Inc.
P. O. Box 68602
Indianapolis, IN 46268-0602
(317) 255-6476.
Price: $325.

Source Language: Microsoft's BASIC-80. Also available in Micro Mike's baZic.
Operating System: CP/M
Minimum System Requirements: Microsoft BASIC-80 (Release 5.03 or later) or Micro Mike's baZic, 190KB disk storage, video display.
Documentation: Includes formulae used in calculations.
Factors for Consideration:
-- Menu-driven software makes MICROSTAT somewhat more approachable than other statistical packages lacking this feature.
-- The file structure used by MICROSTAT makes file transfer difficult. Data to be analyzed by MICROSTAT will in most instances have to be keyed under MICROSTAT's control. The documentation does describe the file structure.
-- The maximum number of cases or variables does not appear to be stated in the documentation.

Name: <u>MicroSURVEY</u>.
Type: Statistical software.
Manufacturer:
Systematica
112 Strand
London WC2R 0AA
United Kingdom
01-836-9379 Telex: 298-648 MARVOR G.
Price: 1,200 Pounds Sterling.
Source Language: FORTRAN.
Operating System: CP/M.
Minimum System Requirements: 64KB RAM.
Factors for Consideration:
-- Handles heirarchical data files.
-- Consists of 4 programs, MVEDIT, MVMREC, MVTAB and MBREGR.
-- MVEDIT performs range checks on all variables and consistency checks within and between levels of heirarchy.
-- MVMREC performs arithmetic and conditional transformations and allows the creation and deletion of new variables.
-- MVTAB supports three levels of heirarchy, tables of up to four dimensions, and up to 10 tables in a single pass of the data. Performs both counts and sums of weighted values. Percentage tables are optional.

Name: <u>Northwest Analytical STATPAK</u>.
Type: Statistical software.
Manufacturer:
Northwest Analytical Inc.
1532 S. W. Morrison Street
Portland, OR 97205
(503) 224-7727.

Price: $500.
Source Language: MBASIC.
Operating System: CP/M.
Minimum System Requirements: 48KB RAM and Microsoft BASIC v5.xx.
Factors for Consideration:
-- STATPAK offers a wide range of statistical tests and data handling functions.
-- The interactive nature of the collection of programs offered may be helpful to some users, but the questions asked by the software are often obscure in meaning and require frequent reference to the manual. To others making repetitive use of the software, the need to respond to the same questions in the same manner time after time will soon seem burdensome.
-- The inability to perform more than one task on a pass through a data file is a considerable disadvantage.
-- Preparation of data files for use with STATPAK may be difficult. The requirement that variables be separated by a blank or some other delimiter will make many data files incompatible. A utility such as SuperSort that could be used in creating files containing only one or two variables is a helpful tool in working with this package.

Name: SL-Micro.
Type: Statistical software.
Manufacturer:
Ray and Alice Kalush
Questionnaire Service Company
P. O. Box 23056
Lansing, MI 48909
(517) 641-6962.
Price: $250.
Source Language: CBASIC. The source code is not available but a compiled version is available that does not require CBASIC run-time support.
Operating System: CP/M.
Minimum System Requirements: 48KB RAM, two disk drives are recommended.
Documentation: Limited, but adequate if SPSS documentation is available.
Factors for Consideration:
-- Uses SPSS commands and formatting of output. Anyone knowing SPSS can use SL-Micro with little further training.
-- The SPSS commands VARIABLE LIST, INPUT MEDIUM, N OF CASES, INPUT FORMAT, MISSING VALUES, VALUE LABELS, VAR LABELS, RECODE, COMPUTE, IF, SELECT IF, FREQUENCIES (with options HISTOGRAM and STATISTICS), CONDESCRIPTIVE, CROSSTABS (with options ROW, COLUMN and TOTAL), PEARSON CORR (with options T-STATISTIC, MEAN and COVARIANCE) and REGRESSION have been implemented.
-- Frequencies must not exceed 32,600.

-- Up to 200 variables may be defined.
-- Up to 100 crosstabulations may be specified. Approximately 500 cells may be generated in each program run.
-- SL-Micro reads standard CP/M files, allowing easy access to data transferred from a mainframe computer or output from Pascal, COBOL, or FORTRAN programs.
-- There is no provision for summation or for weighted data.

Name: SURVTAB (Version IBM.1.0).
Type: Statistical software.
Manufacturer:
Statistical Computing Consultants
9025 Andromeda Drive
Burke, VA 22015
(703) 455-2379.
Price: $180.
Source Language: IBM PC BASIC.
Year of First Release: 1982.
Operating System: IBM PC-DOS.
Minimum System Requirements: 64KB RAM, DOS with BASICA, monochrome or color monitor, and one floppy disk drive (two are recommended).
Factors for Consideration:
-- Menu-driven software makes SURVTAB more approachable for new or occasional users.
-- Number of questionnaires is limited only by disk capacity.
-- Eighty items are allowed per questionnaire.
-- Up to 15 categories are allowed for any precoded item.
-- Includes a data entry subsystem and a data analysis subsystem. The latter supports the production of frequency distributions for precoded items, cross tabulations of pairs of precoded items, and summary statistics for continuous variables.

Name: STATPRO.
Type: Statistical and graphics software package.
Manufacturer:
Wadsworth Electronic Publishing Company
20 Park Plaza
Boston, MA 02116
(617) 423-0420.
Price: STATPRO is sold in modules. The statistics module costs $250; the plotting module costs $250. Both modules with multivariate analysis capability sell for $500. Additional modules for mailing, library management, inventory, payroll, and communications are available. The total package costs $1995.
Source Language: UCSD Pascal.
Operating System: UCSD Pascal for the Apple II and Apple III. (A version for the IBM PC is planned for 7/83.)

Minimum System Requirements: The system was developed for a floppy-based Apple system and a CORVUS Omninet network.

Factors for Consideration:

-- Based on Blue Lakes Software's Statpro.
-- Allows 24 fields per record.
-- Supports files of 32,767 records with a hard disk drive.
-- Includes extensive color graphics capability.
-- Offers a VisiCalc interface.

### 10.2.3 Graphics Software

Name: Apple II Business Graphics.
Type: Graphics software.
Manufacturer:
Apple Computer
10260 Bandley Drive
Cupertino, CA 95014
(408) 996-1010.
Price: $175.
Operating System: Apple II DOS.
Minimum System Requirements: 48KB RAM, two disk drives, language card, black and white or color monitor. Business Graphics was designed to work with the Apple Silentype, the HP 7225A/B, Houston Instruments HIPLOT and the Qume Sprint 5/45. Check on the availability of other printer and plotter interfaces.
Documentation: Manual follows typical Apple format and includes a good tutorial. A reference card is included.
Factors for Consideration:

-- Supports pie charts, bar charts, and line graphs.
-- Labels can be easily moved about on display. Only one size lettering is available.
-- Easy to enter and modify data.
-- Screen images can be saved in disk files.
-- Not particularly well matched with the Pkaso interface. The size of generated charts and graphs cannot be easily changed.

Name: Chartman.
Type: Graphics software.
Manufacturer:
Graphic Software Inc.
P. O. Box 367, Denmore Station
Boston, MA 02215.
Price: $380.
Operating System: IBM PC-DOS.
Minimum System Requirements: Interfaces for most graphics printers are available. Supports HP 7000 series plotters.

Name: <u>Chart-Master</u>.
Type: Graphics software.
Manufacturer:
Decision Resources
P. O. Box 309
Westport, CT 06881
(203) 222-1974.
Price: $375.
Operating System: IBM PC-DOS.
Minimum Systems Requirements: Support for HP 7000 series and 9872 plotters.

Name: <u>GrafTalk</u>.
Type: Graphics software.
Manufacturer:
Lifeboat Associates
1651 Thrid Avenue
New York, NY 10028
(212) 860-0300 TWX: 710-581-2524 (LBSOFT NYK)
Telex: 640 693 (LBSOFT NYK).
Price: $450.
Operating System: CP/M.
Minimum System Requirements: A wide variety of printer interfaces (or modifications) are available.

Name: <u>Series PGL Business Graphics System</u>.
Type: Graphics software.
Manufacturer:
Peachtree Software Incorporated
3 Corporate Square, Suite 700
Atlanta, GA 30329
(404) 325-8533.
Price: $400.
Operating System: CP/M.

Name: <u>The Prime Plotter</u>.
Type: Graphics software.
Manufacturer:
Primesoft Corporation
P. O. Box 40
Cabin John, MD 20818
(301) 229-4229.
Price: $240.
Operating System: Apple II DOS 3.3.
Minimum System Requirements: 48KB RAM, language card, at least one disk drive, a printer. A graphics interface card such as the Grappler or Pkaso is recommended.
Factors for Consideration:
-- Mostly menu-driven.
-- Provides an interface for DIF files.

### 10.2.4 Data Entry Software

Name: DataStar.
Type: Data entry software.
Manufacturer:
MicroPro International Corporation
1299 Fourth Street
San Rafael, CA 949C1
(415) 457-8990 Telex: 340-388.
Price: $350.
Operating System: CP/M.
Factors for Consideration:
-- Provides for flexible key-to-disk data capture.
-- Menu driven.

Name: RADAR II (Version 3.8).
Type: Data entry software.
Manufacturer:
Southern Computer Systems, Inc.
P. O. Box 33734
Birmingham, AL 35255
(205) 933-1659.
Price: $495. Normally, RADAR II is sold as a package of at least 6 licenses. When 6 are purchased, the cost is $400 per license.
Source Language: 8080 assembly language.
Operating System: CP/M, MP/M.
Factors for Consideration:
-- Provides an IBM 3741-style key-to-disk environment.
-- Provides full data editing capability.
-- Supports data verification.
-- Provides support for check digits.
-- Allows automatic and manual duplication of fields.

### 10.2.5 Word Processing Software

Name: Final Word.
Type: Word processing software.
Manufacturer:
Mark of the Unicorn, Inc.
P. O. Box 423
Arlington, MA 02174
(617) 489-1387.
Price: $300.
Source Language: C.
Operating System: CP/M-86, IBM PC-DOS, MS-DOS, UNIX, XENIX.
Minimum System Requirements: 56 KB RAM, video termi l with cursor positioning character sequences.
Factors for Consideration:
-- Provides for footnoting, table of contents and chapter numbering.

Name: <u>Perfect Writer</u>.
Type: Word processing software.
Manufacturer:
Perfect Software Inc.
1400 Shattuck Avenue
Berkeley, CA 94709
(800) 227-5488.
Price: $495.
Operating System: IBM PC-DOS.
Factors for Consideration:
-- Has footnoting capability.
-- Provides for split screen displays.

Name: <u>PIE Writer</u>.
Type: Word processing software.
Manufacturer:
Hayden Software
600 Suffolk Street
Lowell, MA 01853
(800) 343-1218.
Price: 149.95 for the Apple II; 199.95 for the IBM PC.
Operating System: Apple II DOS; IBM PC-DOS.

Name: <u>Superwriter</u>.
Type: Word processing software.
Manufacturer:
Sorcim Corporation
405 Aldo Avenue
Santa Clara, CA 95050
(408) 727-7634.
Price: $395.
Operating System: CP/M, CP/M-86, IBM PC-DOS.

Name: <u>WordStar (Version 3.0)</u>.
Type: Word processing software.
Manufacturer:
MicroPro International Corporation
1299 Fourth Street
San Rafael, CA 94901
(415) 457-8990 Telex: 340-388.
Price: $495.
Operating System: CP/M, Apple II, IBM PC-DOS.
Minimum System Requirements: 45KB RAM, two floppy disk drives, an ASCII terminal (preferably with at least 24 lines by 80 columns, but no more than 120 lines by 250 columns) that should be among the dozen or so that WordStar will support without custom modification, and a printer, again selected from a list of printers supported by WordStar or able to operate as a teletype-like printer.
Documentation: Good, complete documentation.
Factors for Consideration:
-- A standard for microcomputer word processing software.

-- Allows editing of non-document files such as computer programs and data files.
-- A number of books on WordStar are available.

Name: WRITE.
Type: Word processing software.
Manufacturer:
Ashton-Tate
9929 West Jefferson Blvd.
Culver City, CA 90230
(213) 204-5570.
Price: $395.
Operating System: CP/M.

## 10.3 High-Level Language Processors

BASIC is the predominant language used on microcomputers today. BASIC interpreters are virtually standard equipment on smaller systems, and they are such useful tools that one should be purchased even if it is not to be the primary language to be used on the system. As a language, BASIC has some decided advantages. It is easy to learn, due to the small number of its commands, and, as an interpreter, it makes the development of small programs very easy. It has disadvantages that cannot be overlooked, however. In its interpreted versions, BASIC tends to be very slow. It also uses a peculiar file structure that is seldom compatible with packaged software that has not been written with the same version of the language.

Fortunately, a wide range of languages is available for microcomputers. Pascal is probably the next best supported language on microcomputers after BASIC, but FORTRAN, COBO', and PL/I are also available. Pascal and FORTRAN compilers and pseudocompilers often support separate compilation of program modules or subroutines. Chaining and overlay capability may be available with BASIC, Pascal, and FORTRAN language processors. Implementations of COBOL under CP/M are technically impressive, but it is not advisable to consider development or processing of large COBOL programs on a small microcomputer because of the space requirements of COBOL source and object code.

Interpreters allow faster program development than compilers by making it easy to test and debug source code. Some compiler developers have taken this to heart and made their compilers easier to use by adding a source code editor that performs quick syntax checks on the source code. Perhaps the most favorable program development environment is one in which programs are developed with the use of an interpreter and subsequently compiled for faster execution once all development problems have been resolved. To be feasible, the interpreter and compiler must have complete syntactical compatibility.

If speed is a major consideration, programs created with compilers generating native microprocessor code tend to be faster in execution than programs created by those pseudocompilers that generate a machine independent intermediate code, although they may require much more time for compilation. Interpreted programs are generally slower in execution than either compiled or pseudocompiled programs. If size of compiled code is a consideration, pseudocompilers usually outperform true compilers.

Compilers and interpreters may place surprising restrictions on the amount of memory that may be used even when more memory is available. For example, MBASIC provides only about 32KB of program and data storage under CP/M even though the microcomputer has 64KB of RAM; the remaining space is taken up by operating system and interpreter code. Also, Pascal/MT+86, a version of the CP/M Pascal/MT+ compiler for CP/M-86, might be expected to be able to use the full 1MB of RAM available under CP/M-86 systems; but, in fact, it is limited to only 64KB for program storage and 64KB for data storage. If the use of memory is important to the success of a particular programming task, the compiler's limitations should be checked carefully. Few 16-bit microcomputer compiler implementations allow full use of the increased memory available with these systems.

References to the availability of language interpreters and compilers for a particular operating system found in advertisements or vendor materials should be independently verified. There is much talk of the availability of software long before the fact. Occasionally packages that are planned are never developed. The consequence of aggressive advertising and premature claims has been a blurring of the distinction between plan and reality.

General guidelines:

A BASIC interpreter is very useful software and should be purchased, if it is not provided with the microcomputer procured. Compilers are useful when fast program execution is important (with large data files, for example). Pascal, FORTRAN, COBOL, and even a version of PL/I are available, but on small microcomputers, these languages may be limited implementations of a recognized standard. If COBOL is to be used, plans should not be made for processing large COBOL programs on small microcomputers. Overlay and chaining capability is a desirable option, as is the ability to compile program modules separately. In every case, it is advisable to talk with someone having experience with the interpreter or compiler that has been selected.

### 10.3.1 BASIC

- -- BASIC compilers and interpreters vary enormously in such things as conventions for designating variable types and assigning names to variables, input/output command formats and the use of line numbers. This variability makes it difficult to move application programs written in one

implementation of BASIC to another interpreter or compiler except where specific provisions have been made for compatibility.

-- The proposed ANSI standard for BASIC and the problems that have been faced in its adoption are described by Ronald Anderson in the article "The Proposed ANSI BASIC Standard" (BYTE Magazine, Vol. 8, No. 2 (2/83), pp. 194ff.).

Name: BASIC Version IV.0.
Type: A BASIC pseudocompiler.
Manufacturer:
SofTech Microsystems, Inc.
9494 Black Mountain Rd.
San Diego, CA 92126
(714) 578-6105.
Price: $225.
Operating System: UCSD p-System.
Factors for Consideration:
-- Fully integrated with other UCSD p-System pseudocompilers. Program modules written in BASIC can be linked with other modules written in Pascal or FORTRAN.
-- Includes structured extensions for BASIC including the IF, THEN, ELSE construct.

Name: BASCOM.
Type: BASIC compiler.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $395.
Operating System: CP/M, Apple II Softcard, TRS-80 Models I and II.
Minimum System Requirements: 48KB, one disk drive.
Factors for Consideration:
-- Designed to be compatible with MBASIC but generates optimized 8080 or Z80 machine code.
-- Execution times typically 3 to 10 times faster than MBASIC.
-- A review of BASCOM can be found in an article by Jon Lindsay entitled "Finely-Tuned Basic Compiler" in Microcomputing, Vol. VI, No. 8 (8/82), pp. 48ff.

Name: BaZic.
Type: BASIC interpreter and compiler.
Manufacturer:
Micro Mike's Inc.
1009 S. Virginia
Amarillo, TX 79102
(806) 372-3633.

Price: $150.
Source Language: Z80 assembler.
Operating System: CP/M and North Star DOS.
Minimum System Requirements: 32KB, two disk drives, a 24-line screen.
Factors for Consideration:
- -- Supports binary coded decimal (BCD) arithmetic for accuracy to 14 digits.
- -- A fast 8-bit BASIC interpreter.
- -- Can be configured to provide cursor handling on a variety of CRT's.

Name: CB-80 1.3.
Type: BASIC compiler.
Manufacturer:

Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.

Price: $500.
Operating System: CP/M 2.X and MP/M II.
Minimum System Requirements: 48KB RAM.
Factors for Consideration:
- -- Designed to be compatible with CBASIC.
- -- Compilation speed is 700 lines per minute (from a hard disk).
- -- Permits strings of 32,000 bytes (rather than the normal 255 bytes).
- -- Allows locking of files and records in support of multiuser operating system environments.
- -- Supports extended precision arithmetic (at least 14 significant digits).

Name: CBASIC 2.8.
Type: A BASIC pseudocompiler. CBASIC compiles BASIC code to an intermediate code that requires a run-time interpreter for execution. It does not offer line-by-line execution of code as does an interpreter.
Manufacturer:

Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.

Price: $150.
Operating System: CP/M and MP/M II.
Minimum System Requirements: 24KB RAM (48KB is recommended).
Factors for Consideration:
- -- Line numbers are optional and labels are supported, contributing to more readable BASIC code.
- -- CBASIC has an impressive array of predefined functions.

Name: CBASIC-86 1.1.
Type: A BASIC pseudocompiler. See comments for CBASIC.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $325.
Operating System: CP/M-86 and MP/M-86.
Minimum System Requirements: 32KB RAM (48KB is recommended).
Factors for Consideration:

- -- Earliest implementations of CBASIC-86 imposed the same 64KB restriction that had been part of CBASIC under CP/M.
- -- Designed to be compatible with CBASIC.

Name: MBASIC or BASIC-80 (Release 5.0).
Type: BASIC interpreter.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $350.
Year of First Release: 1975.
Operating System: CP/M and MP/M II.
Minimum System Requirements: 32KB RAM, one disk drive.
Factors for Consideration:

- -- MBASIC offers the ease of use and ease in debugging that interpreters offer.
- -- MBASIC has been widely adopted and used and is something of a standard in its own right.
- -- Supports double-precision floating-point arithmetic (16-digits).

## 10.3.2 Pascal

- -- There are incompatibilities between the major versions of Pascal, especially in features that are extensions to the standards. These extensions, nevertheless, help to alleviate some of Pascal's more notable weaknesses in input/output and string handling.

Name: Pascal/MT+86 3.0.
Type: Pascal compiler.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.

Price: $600.
Operating System: CP/M-86 and MP/M-86.
Minimum System Requirements: 108KB RAM after operating system is loaded.
Factors for Consideration:
- -- Designed to be compatible with Pascal/MT+.
- -- Provides support for the Intel 8087 numeric processor chip.
- -- A text editor for program editing that performs syntax checking is available.
- -- There are 64KB limits on code, data and the stack, but dynamic allocation can utilize the full 1MB supported by CP/M-86.

Name: Pascal/MT+ 5.5.
Type: Pascal compiler.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $350.
Operating System: CP/M and MP/M II.
Minimum System Requirements: 48KB RAM after operating system is loaded (56KB is recommended) and at least 150KB of disk space.
Factors for Consideration:
- -- A native code compiler with superior execution speed.
- -- Generates relocatable and ROMable code.
- -- Supports modular compilation and overlays.
- -- A superset of the ISO standard.
- -- Preparation of code for execution involves compilation and linkage with a run-time subroutine library.
- -- The package includes a compiler, a linker, a disassembler, a debugger and a run-time subroutine library.
- -- A text editor for program editing that performs syntax checking is available.

Name: Pascal-M.
Type: Pascal pseudocompiler for Z80 and 8080/8085 systems.
Manufacturer:
Sorcim Corporation
405 Aldo Avenue
Santa Clara, CA 95050
(408) 727-7634.
Price: $225.
Operating System: CP/M 2.0, MP/M, OASIS.
Documentation: Sorcim's documentation is said to be good.

Factors for Consideration:
- -- Package includes the compiler, a run-time library, and a run-time interpreter. The compiler produces p-code output.
- -- Pascal-M's handling of end-of-line markers is not well-matched with CP/M.
- -- Very fast compiler with complete and informative error messages.
- -- Does not provide for separate compilation of procedures.
- -- Allows memory overlays.

Name: <u>Pascal-Z</u>.
Type: Pascal compiler for the Z80 processor.
Manufacturer:
Ithaca Intersystems Inc.
1650 Hanshaw Road
Ithaca, NY 14850
(607) 257-0190 TWS: 510 4346 TWX: 510 255 4346.
Price: $395.
Operating System: CP/M 2.2.
Minimum System Requirements: 56KB RAM, one disk drive (two are recommended).
Factors for Consideration:
- -- Includes assembler and linker. Execution involves compilation, assembly of Z80 assembler code, and link of resulting code to run-time library.
- -- Generates ROMable code.
- -- There is a Pascal-Z user's group that maintains a large body of public domain software.
- -- Supports memory overlays, separate compilation, and chaining.

Name: <u>Pascal-2 MC68000</u>.
Type: Pascal compiler.
Manufacturer:
Oregon Software
2340 S.W. Canyon Road
Portland, Oregon 97201
(503) 226-7760 TWX: 910-464-4779.
Price: $5,950 for VERSAdos version.
Year of First Release: 1982.
Operating System: VERSAdos.

Name: <u>UCSD Pascal 4.0</u>.
Type: A Pascal pseudocompiler. UCSD Pascal is compiled to p-code which requires a run-time interpreter for execution.
Manufacturer:
SofTech Microsystems, Inc.
9494 Black Mountain Rd.
San Diego, CA 92126
(714) 578-6105.

Price: $500.
Operating System: UCSD p-System.
Minimum System Requirements: 48KB contiguous RAM (64KB are recommended) and 175KB of disk storage.
Factors for Consideration:
- -- The UCSD p-System is remarkably portable and is available for a variety of microcomputer systems.
- -- The package includes a one-pass compiler, a macro assembler, a linker and a librarian utility.
- -- Data files are incompatible with CP/M but programs are available to perform the necessary conversions.

Name: Whitesmith's Pascal.
Type: Pascal compiler.
Manufacturer:
Whitesmith's Limited
Parkway Towers 'B'
485 U. S. Route 1 South
Iselin, New Jersey 08830
(201) 750-9000 Telex: 645592.
Price: $950 and up.
Operating System: Available for 10 operating systems including ISIS-II, CP/M, Idris/B80, VERSAdos, Idris, and UNX/32V.

### 10.3.3 FORTRAN

Name: FORTRAN-77.
Type: FORTRAN pseudocompiler.
Manufacturer:
SofTech Microsystems, Inc.
9494 Black Mountain Rd.
San Diego, CA 92126
(714) 578-6105.
Price: $375.
Operating System: UCSD p-System.
Factors for Consideration:
- -- ANSI-77 FORTRAN subset.
- -- Compatible with the UCSD p-System BASIC and Pascal pseudocompilers. Modules from different languages can be linked into a single program.

Name: FORTRAN-80.
Type: FORTRAN compiler.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $500.
Operating System: CP/M 2.X, Apple II Softcard, TRS-80 Model II.

Minimum System Requirements: 32KB.
Factors for Consideration:
- -- Includes full ANSI Standard FORTRAN X3.9-1966 except the COMPLEX data type.
- -- Maximum files of 65,536 records or 8MB.
- -- Supports INTEGER*4, allowing integer values of more than 2 billion to be used.
- -- Diagnostic messages are limited.
- -- Both compilation and execution speeds are good.
- -- User may write non-standard I/O drivers for each logical unit number.

Name: FORTRAN-86.
Type: FORTRAN compiler.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $300 for IBM PC version.
Factors for Consideration:
- -- FORTRAN-86 was notoriously bug-ridden in its earliest versions.

## 10.3.4 COBOL

Name: CIS COBOL 4.4.
Type: A COBOL pseudocompiler with a run-time system of 24KB to 33KB.
Manufacturer:
Micro Focus Inc.
1601 Civic Center Drive
Santa Clara, CA 95050
(408) 496-0176 Telex: 278-704 MFCIS UR.
Price: $800.
Year of First Release: 1978.
Operating System: CP/M, CP/M-86, and UNIX. (Apple also markets a Micro Focus COBOL.)
Factors for Consideration:
- -- The General Services Administration has certified that CIS COBOL meets the ANSI X3.23-1974 standard at the low-intermediate level.
- -- Offers a multiple machine additional use license option for those who wish to run the compiler on more than one computer at a single location.
- -- Micro Focus offers a utility called FORMS-2 that assists in the generation of COBOL source code.

Name: COBOL-80.
Type: A COBOL pseudocompiler. COBOL-80 requires a run-time interpreter.

Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $750.
Operating System: CP/M, Apple II Softcard, TRS-80 Model II, IBM PC.
Minimum System Requirements: 48KB RAM.
Factors for Consideration:
-- Compiles at speeds between 150 and 300 lines per minute.
-- Package includes compiler, linker, macro assembler, cross reference generator, run-time library and librarian.
-- MS-COBOL has been validated by the General Services Administration as a low-intermediate implementation of ANSI 74 requirements. It is said to combine the "most useful" Level 1 and Level 2 ANSI 74 features.
-- Relocatable object code can be linked with FORTRAN-80 object modules using the Microsoft linker.
-- Supports sequential, line sequential, relative random-access and indexed sequential files.

Name: Level II COBOL.
Type: Cobol pseudocompiler.
Manufacturer:
Micro Focus
1601 Civic Center Drive
Santa Clara, CA 95050
(415) 856-4161 Telex: 278-704 MFCIS UR.
Price: $1600.
Source Language: Level II COBOL subset. The run-time system is available in 8080 and 8086 native code and C.
Operating System: CP/M, MP/M, CP/M-86, MP/M-86, UNIX, XENIX, PC-DOS, MS-DOS.
Factors for Consideration:
-- An implementation of the ANSI X3.23-1974 COBOL standard. The compiler has been validated by the General Services Administration at the Federal high level.

Name: MBP COBOL.
Type: COBOL compiler.
Manufacturer:
MBP Software and Systems Technology
7700 Edgewater Drive, Suite 626
Oakland, California 94621
(415) 632-1555.
Price: $500.
Operating System: CP/M-86, MS-DOS (OASIS-16 and MP/M-86 versions are planned.)
Minimum System Requirements: 80KB, 1.5MB hard disk drive.

Factors for Consideration:
-- Generates 8086 machine code in relocatable format.
-- Allows for 64KB code (approximately 6,400 lines of source code) and 64KB data.
-- Compilation at speeds up to 350 lines per minute (depending on hardware).
-- Based on the ANSI '74 Level II standard.
-- Early versions of this package were not bug-free. Refer to Chapter 17 for more complete details.

Name: RM/COBOL (RSCOBOL for TRS-80 Model I and III systems).
Type: COBOL pseudocompiler.
Manufacturer:
Ryan-McFarland Corp.
Software Products Group
9057 Soquel Drive
Aptos, CA 95003
(408) 662-2522 TWX 910-598-4507.
Price: $950 for OASIS Multiuser System, $700 for the IBM PC version, and $199 for TRS Model I and III versions.
Operating System: CP/M 2.X, MP/M II, CP/M-86, OASIS, UNIX V7, PC-DOS, TRS-DOS, RT-11, TI 990, ZEUS.
Factors for Consideration:
-- Implementation of COBOL based on the ANSI X3.23-1974 standard.
-- Provides level-2 sequential, relative and index file access methods.
-- Supports source program segmentation.
-- A review of RSCOBOL by Rowland Archer, Jr. entitled "COBOL for the TRS-80 Models I and III" can be found in BYTE Magazine, Vol. 7, No. 3 (3/82), pp. 384ff.

10.3.5 PL/I

Name: PL/I-80 1.3.
Type: A PL/I compiler for 8080/8085 and Z80 systems.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $500.
Operating System: CP/M 2.X and MP/M II.
Minimum System Requirements: 48KB RAM.
Factors for Consideration:
-- Based on the ANSI standard, Subset G.
-- Generates optimized machine code with superior execution speed.
-- Package includes a compiler, a macro assembler, a linker, a librarian, and a cross-reference generator.

-- Provides support for multiuser systems, allowing files to be locked, shared, or read-only with password suf 'ort. Individual records may be locked as well.
-- Th three-pass compiler runs at about 500 lines per minu.e.

## 10.4 Operating Systems

Operating system software is generally developed by an independent software house and is subsequently sold to a microcomputer vendor after the modifications necessary to adapt it to the vendor's particular hardware configuration have been made. The consequence of this is that there are only a few major microcomputer operating systems even though there are hundreds of microcomputer vendors. A microcomputer vendor may develop its own operating system, although this is the exception rather than the rule. (In terms of number of systems, however, the exceptions may be very important, as Apple Computer has demonstrated.) It is advisable to choose one of the more popular operating systems, even at the expense of power or performance, to insure that application and support software will be available in both quantity and acceptable quality.

Some microcomputer systems marketed today offer a choice of operating systems. There is an advantage to this situation in that it provides access to more than one application software marketplace. Software not available for one operating system may be available under another. In cases where more than one operating system is to be used, however, it is important to realize that different operating systems utilize different storage formats and that sharing of data files by different operating systems is likely to be problematic. One notable exception to this is the CP/M family of operating systems. CP/M (for the 8-bit 8080 and Z80 microprocessors) and CP/M-86 (for the 16-bit 8088 and 8086 microprocessors) share a common file structure. As a result, a few microcomputer system integrators have combined dual processor boards providing both 8- and 16-bit microprocessors, with a special implementation of the CP/M operating system that allows both 8- and 16-bit software to be run under the same operating system and to share the same data files.

Operating systems place limits on the amount of memory that may be used. If it is known, therefore, that 100KB of main storage will be required for the compilation or execution of programs, an operating system capable of supporting programs of this size should be selected. When a multiuser system is being considered, it should not be assumed that it will allow a single-user to have access to the full complement of memory that may be supported by the operating system's single-user counterpart.

Operating systems, further, impose restrictions on the size of disk files and the total amount of disk storage that may be used. In most cases, the limits are large, both in terms of the number of records that may be included and in terms of the total file size in

bytes. Nevertheless, if large files are to be used, care should be taken to verify the specific limitations imposed by the operating systems under consideration.

Support for peripheral devices begins at the operating system level. Therefore, if a Winchester disk will be required, it is important to check that the particular implementation of the operating system being offered by the microcomputer system vendor can support the selected disk drive. Peripheral vendors sometimes offer the necessary operating system changes. The effectiveness of the vendor's patch should be independently verified. It should not be assumed that an operating system will be capable of supporting peripherals that are not standard equipment on the system being procured.

Multiuser operating systems are relative newcomers to the microcomputer marketplace and the older of these systems are not terribly robust. A single-user may, without warning or effort, bring the work of all users to an abrupt and unexpected halt by crashing the system. In addition, multiuser systems may place severe limits on the amount of memory available to any one user. These failings, perhaps more than the degradation in processing speed when multiple users are being serviced by a single microprocessor, are the primary drawbacks to the multiuser environment on microcomputers. Program testing is not a good candidate for multiuser work; the execution of production programs, data entry and word processing may be.

General guidelines:

Select a popular operating system to secure access to a substantial application software market. Since operating systems place limitations on such things as memory, file size, and peripheral support, check processing requirements against those of the operating system under consideration. Multiuser operating systems should not be expected to be particularly robust and any plans for their use should take this into account.

### 10.4.1 The CP/M Family of Operating Systems

- -- All members of the CP/M family share a common file structure. This means that files written by a program running under CP/M can be read by programs running under CP/M-86.

- -- CP/M-68K has been released for Motorola 68000-based systems but is not widely available in early 1983.

Name: <u>Concurrent CP/M-86</u>.
Type: Single-user, multitasking operating system.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $350.
Source Language: 8086 Assembler. Source code is available.
Year of First Release: September 1982.
Microprocessors Supported: Intel 8088 and 8086.
Minimum System Requirements: 128KB RAM, real-time clock.
Factors for Consideration:

-- See comments on CP/M-86.
-- Concurrent CP/M-86 supports print spooling.
-- File and record locking functions are offered with support for optional passwords.
-- Maintains independent virtual consoles (typically 4 to 10) to support multitasking. One virtual console is linked to the physical console at a time; all others operate in a background mode. Memory partitions for multiple operations are set at the time of system generation.

Name: <u>CP/M 2.2</u>.
Type: Single-user, single-task operating system.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $150.
Source Language:
CP/M is coded in 8080 assembler. The source code is available, and, with help from documentation from third party sources, it is possible to make modifications. Plans for anything more than simple changes to the Basic Input/Output System (BIOS) are not recommended.
Microprocessors Supported:
CP/M is available for 8080- and Z80-based microcomputer systems. It is available for the Apple II and IBM-PC with the addition of a CP/M card containing a Z80 microprocessor. CP/M simulators are available for other computers.
Minimum System Requirements: 20KB RAM, ASCII console, disk drive.
Year of First Release: 1979. (For earlier versions: 1974.)
Documentation:
The documentation for CP/M from Digital Research is notoriously sparse but other sources for documentation are available. The <u>Osborne CP/M User Guide</u> by Thom Hogan (OSBORNE/McGraw-Hill:Berkeley, California, 1981)

and The CP/M Handbook with MP/M by Rodnay Zaks (Sybex:Berkeley, California, 1980) are two examples of such documentation for CP/M. Software for training in the use of CP/M is also available from third party sources.

Factors for Consideration:

-- An 8-bit industry standard.
-- Supports up to 64KB of RAM; disk files up to 8MB.
-- Has one of the largest collections of applications software available for an operating system. In addition, an active CP/M User's Group makes 50 volumes of software available in the public domain.
-- Has a terse and sometimes confusing command language that offers the user no help. Software enhancements to the system, such as a menu format, help commands and even a UNIX-like shell, are available but they require space from the already limiting 64KB of memory the operating system supports.
-- Shares a common file structure with CP/M-86.
-- A simple operating system that provides little more than the essentials. It does not include, for example, a sort/merge utility, although sort packages are available for it. A more serious omission is the lack of a relocatable linker.
-- Among CP/M's notable weaknesses are its poor error recovery capability and inefficient utilization of disk storage.

Name: CP/M-86 1.1.
Type: Single-user, single-task operating system.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $250.
Source Language: 8086 Assembler. Source code is available.
Year of First Release: 1981.
Microprocessors Supported: Intel 8088 and 8086.
Minimum System Requirements: at least 56KB RAM, disk drive, real-time clock.
Documentation: The documentation provided with CP/M-86 is better than that provided with CP/M but it is still difficult reading.

Factors for Consideration:

-- Manages 1MB of RAM.
-- Supports 1 to 16 disk drives of up to 8MB each. This limit on the size of a disk drive also imposes an 8MB limit on file size.
-- CP/M-86 shares a common file structure with CP/M.
-- The recent release date means that the software available for CP/M-86 is comparatively limited and new.
-- The lack of an adequate FORTRAN compiler for CP/M-86

during 1982 has probably been responsible in part for the failure of major statistical software vendors such as SPSS, P-Stat and BMDP to make these packages available for CP/M-86.

-- For a comparison of CP/M-86 and MS-DOS, see (1) Dave Cortesi, "CP/M-86 vs. MSDOS: A Technical Comparison", Dr. Dobb's Journal, Vol. 7, No. 69 (7/82), pp 14ff. and (2) Roger Taylor and Phil Lemmons, "Upward Migration: A Comparison of CP/M-86 and MS-DOS," BYTE Magazine, Vol. 7, No. 7 (7/82), pp. 330ff.

Name: MP/M II 2.1.
Type: Multiuser, multitasking operating system.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $450.
Source Language: Like CP/M, MP/M II is coded in 8080 assembler. The source code is available.
Year of First Release: 1979.
Microprocessors Supported: MP/M II is available for 8080- and Z80-based microcomputer systems.
Minimum System Requirements: 48KB RAM, real-time clock, one disk drive.
Documentation: MP/M II documentation is Spartan.
Factors for Consideration:

-- MP/M supports up to 7 users with 48KB RAM per user.
-- MP/M supports print spooling, password protection, file and record locking, as well as date and time stamping on disk files. All are useful extensions to CP/M.
-- MP/M is not notably robust.
-- MP/M offers access to the CP/M software marketplace. Much, though not all, CP/M software may be used with MP/M.
-- See the comments for CP/M.

Name: MP/M-86 2.0.
Type: Multiuser, multitasking operating system.
Manufacturer:
Digital Research
P. O. Box 579
160 Central Avenue
Pacific Grove, CA 93950
(408) 649-3896 TWX 910 360 5001.
Price: $650.
Source Language: 8086 Assembler. Source code is available.
Year of First Release: September 1981.
Microprocessors Supported: Intel 8088 and 8086.
Minimum System Requirements: 64KB RAM, real-time clock, disk drive.

Factors for Consideration:
- -- MP/M-86 supports up to 256 users but no more than 16 are recommended.
- -- Most CP/M-86 programs will run under MP/M-86.
- -- See comments on CP/M-86.

### 10.4.2 MS-DOS

Name: MS-DOS.
Type: Single-user, single-task operating system.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: Not available.
Source Language: 8086 Assembler.
Year of First Release: 1981.
Microprocessors Supported: Intel 8086 and 8088.
Minimum System Requirements: 32KB RAM.
Factors for Consideration:
- -- MS-DOS includes linker and library software.
- -- The selection of MS-DOS by IBM for the IBM-PC has made MS-DOS a formidable opponent of CP/M-86.
- -- Supports up to 1.1MB RAM.

### 10.4.3 The UNIX Family of Operating Systems

- -- The Programmer's Workbench, an extensive and powerful set of software tools, is available with some versions of UNIX. It is worth looking for.
- -- Despite the numbering, Level or Version 7 is an earlier release of UNIX than is Version III. In early 1982, UNIX Version IV with software called the Writer's Workbench was reported to be available to commercial customers "soon."
- -- Having been designed for the DEC PDP-11, UNIX typically offers 64KB per user for program storage and 64KB for data storage. This may vary from implementation to implementation.
- -- The command language for UNIX is terse (and sometimes inconsistent). Programmers tend to like it; more occasional users find it difficult.
- -- UniFLEX from Technical Systems Consultants is an operating system "closely modeled" on UNIX that is available for systems based on the 6809 microprocessor.
- -- Other members of the UNIX family include CROMIX and UNIX V7.

Name: XENIX.
Type: Multiuser, multitasking operating system.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: Not available.
Source Language: Written in C. Source code is not available.
Year of First Release: 1981.
Microprocessors Supported: Z8000, 8086, 68000, LSI-11.
Minimum System Requirements: 192KB RAM.
Factors for Consideration:
-- An implementation of UNIX Level 7.
-- Supports up to 25 users and 100 tasks.
-- Offers network support.

### 10.4.4 The OASIS Family of Operating Systems

Name: OASIS.
Type: Multiuser, multitasking operating system.
Manufacturer:
Phase One Systems, Inc.
7700 Edgewater Dr., Suite 830
Oakland, CA 94621
(415) 562-8085.
Price: $850.
Source Language: Z80 assembler. Source code is not available.
Year of First Release: 1979.
Microprocessors Supported: Z80.
Minimum System Requirements: 56KB RAM, 500KB disk storage.
Documentation: Said to be good.
Factors for Consideration:
-- Business-oriented operating system with much "friendlier" user interface than CP/M.
-- Substantial software market with a strong business orientation in software offerings.
-- Supports print spooling.
-- Supports up to 16 users, 16 tasks and 784KB RAM.
-- No network support.
-- Lack of availability of FORTRAN has been a problem.
-- Communications support is included.
-- An IBM 3470 disk formatter package is available.

Name: OASIS-16.
Type: Multiuser, multitasking operating system.
Manufacturer:
Phase One Systems, Inc.
7700 Edgewater Dr., Suite 830
Oakland, CA 94621
(415) 562-8085.
Price: $1495.

Source Language: OASIS-16 has been coded in C to promote portability. The source code is not available.
Year of First Release: 1982.
Microprocessors Supported: 8086/8088. The Motorola 68000 chip is "targeted".
Minimum System Requirements: 128KB RAM, 1MB disk storage.
Factors for Consideration:
- -- Supports 32 users, 32 tasks and 128 gigabytes of disk storage.
- -- AN IBM 3470 disk formatter package is available.
- -- Networking support is available.
- -- Supports print spooling.

### 10.4.5 UCSD p-System Software

Name: UCSD p-System Software.
Type: Single-user, multitasking operating system.
Manufacturer:
SofTech Microsystems, Inc.
9494 Black Mountain Rd.
San Diego, CA 92126
(714) 578-6105.
Price: $375.
Source Language: p-System operating systems are coded in UCSD Pascal and CPU assembly language. The source code is available.
Year of First Release: 1977.
Microprocessors Supported: 6502, Z80, 8080, 6809, 9900, 8086, LSI-11.
Minimum System Requirements: 64KB, 175KB disk storage.
Factors for Consideration:
- -- Supports up to 128KB RAM.
- -- A portable operating system available for a variety of systems ranging from the Apple II to Motorola 68000-based systems.

## 10.5 Support Packages

### 10.5.1 Communication Software

- -- Communication software is generally designed for a particular CRT terminal (or, perhaps, a selection of terminals) and a particular serial interface and/or modem, and it is very sensitive to equipment substitution. It is advisable to meet the requirements exactly since modification of the software may not be possible.

- -- Transmission speeds with asynchronous communication packages are usually no greater than 1200 baud, though some packages will support 9600 baud rates when a direct connection is being used.

-- Some communication packages offer parity checking, a feature that is useful for checking the integrity of data that is being transferred.

Name: ASCOM 2.0.
Type: Asynchronous communication software.
Manufacturer:
Dynamic Microprocessor Associates
545 Fifth Avenue
New York, NY 10017.
Price: $175.
Operating System: IBM PC-DOS, MS-DOS, CP/M-86, CP/M.

Name: Crosstalk (and Crosstalk-16).
Type: Asynchronous communication software.
Manufacturer:
Microstuf, Inc.
1900 Leland Drive, Suite 12
Marietta, GA 30067
(404) 952-0267.
Price: $195.
Operating System: CP/M, CP/M-86, MS-DOS. Crosstalk software is sold for selected CP/M-based systems only. Microstuf provides code that is configured for particular systems.

Name: LogOn.
Type: Asynchronous communication software.
Manufacturer:
Ferox Microsystems Inc.
1701 North Fort Myer Drive, Suite 611
Arlington, VA 22209
(703) 841-0800.
Price: $150.
Source Language: UCSD Pascal.
Operating System: UCSD Pascal for the IBM PC, Apple II and Apple III, and TRS-80 Mod II.

Name: P-TERM.
Type: Asynchronous communication software.
Manufacturer:
Southwestern Data Systems
10761-E Woodside Avenue
Santee, California 92071
(714) 562-3670.
Price: $125
Operating System: Apple II Pascal Version 1.1
Minimum System Requirements:
Documentation: Excellent documentation.

Factors for Consideration:
-- Supports transmission rates up to 2400 baud.
-- Supports all Apple compatible modems.
-- Supports all asynchronous serial cards.

Name: Softerm.
Type: Asynchronous communication software.
Manufacturer:
Softronics
6626 Prince Edward Place
Memphis, TN 38139
(901) 755-5006.
Price: $150.
Operating System: Apple II DOS.
Documentation: Documentation includes thorough index.
Factors for Consideration:
-- Softerm is able to emulate 13 popular commercial asynchronous communications terminals
-- A review of the package can be found in Frank Derfler's "Dial-Up Directory" column in Microcomputing, Vol. VII, No. 1 (1/83), p. 8.

Name: TERM II.
Type: Asynchronous communication software.
Manufacturer:
SuperSoft
P. O. Box 1628
Champaign, IL 61820
(217) 359-2112.
Price: $200.
Source Language: 8080 assembler.
Operating System: CP/M.
Minimum System Requirements: Potomac Micro-Magic Modem Board, Hazeltine 1500 CRT terminal.
Factors for Consideration:
-- The modifications necessary to adapt TERM II to a particular hardware configuration other than the one for which it was developed may be difficult.

## 10.5.2 Sort/Merge Utilities

Name: M/SORT.
Type: Sort/merge utility.
Manufacturer:
Microsoft, Inc.
10700 Northup Way
Bellevue, WA 98004
(206) 828-8080.
Price: $195.
Source Language: Machine-independent macro language.
Operating System: CP/M, Apple II Softcard, TRS-80 Model II.
Minimum System Requirements: 48KB RAM.

Factors for Consideration:
- -- Handles file sizes to 2 billion bytes.
- -- Will accept custom user code.
- -- Supports Microsoft file formats and data types.
- -- Can be used by COBOL-80.

Name: SuperSort.
Type: Sort/merge utility.
Manufacturer:
MicroPro International Corporation
1299 4th Street
San Rafael, CA 94901
(415) 457-8990 Telex: 340-388.
Price: $225.
Source Language: 8080 assembler.
Operating System: CP/M, MP/M II.
Minimum System Requirements: 26KB RAM, floppy disk.
Documentation: A technical but thorough and readable manual.
Factors for Consideration:
- -- Sorts or merges up to 32 files into a single output file.
- -- Allows file sizes up to 8MB, the CP/M limit.
- -- Handles up to 65,000 records per file.
- -- Supports a wide range of file formats and data types.
- -- Can be used with Microsoft COBOL.
- -- Will accept custom user code.
- -- A fast and flexible package useful in reformatting data files for use with different statistical packages or with programs generated by different compilers.

## 10.6 Future Trends in Microcomputer Software

Several predictions about the future of microcomputer software made by people close to the industry will be of interest to NSO managers.(3) First, it is predicted that, with new microprocessor chips and increased memory capacity, operating systems will become more sophisticated and more powerful. Single-user, virtual memory operating systems should soon be a reality. In addition, as operating system software improves, timesharing is expected to become more popular as users seek to force the cost of computing to its lowest point.

As microcomputer capacity increases, standard high-level languages like FORTRAN and COBOL will become more common in the microcomputer marketplace and will be more widely used. One implication of this is that, in time, much software currently available for mainframe computers will be available for microcomputers. In addition, software development tools that can assist in the development of high-level language programs for customized use are expected to proliferate.

In application software the trend is towards better integration of a variety of typical office functions. Packages such as Lotus Software's 1-2-3 and VisiCorp's VisiOn are examples of software

developers' attempts to ease the problems of managing both text and data in an office environment. The previously isolated tasks of word processing, spread sheet development, and the generation of charts and graphs have been combined into a single integrated package. Unfortunately, there is little reason to expect that similar efforts will be directed at the specialized functions of statistical offices.

Attempts to move away from the keyboard as the primary user interface should lead to the development of software capable of accommodating a variety of new input devices. The "mouse" used on Apple's Lisa computer is only a precursor of many creative attempts to simplify the way in which the user can direct the computer's operation. The understandings of researchers working in the field of artificial intelligence may also lead to profound changes in software that manages the user/machine interface.

# FOOTNOTES

1 Norman Nie, speaking to the Washington, DC chapter of ISSUES, the SPSS user's group, on 7/15/82.

2 The list of software packages for microcomputers included in this section is by no means exhaustive. Application and support software packages have been included for one of the following reasons: (1) We had hands-on experience with the package and found it acceptable. (2) We spoke with a satisfied user of the package. (3) Articles in the literature offered a favorable review of the package, urging its inclusion. (4) The package was reputed to have at least one unusual and useful feature that set it apart from other packages. We have tried to be as complete as possible in listing compilers available for the operating systems reviewed. Operating systems were selected on the basis of their availability for a wide selection of vendor's equipment. References to reviews in the literature that may be useful have been included where possible. Additional references may be found in Chapter 4 above.

3 For two treatments of what the future will hold, see (1) Daniel H. Marcellus, "A Fearless Look at Micro Changes," <u>Microcomputing</u>, Vol. VII, No. 3 (3/83), pp. 119-121, and (2) Gregory S. Blundell, "Personal Computers in the Eighties," <u>BYTE Magazine</u>, Vol. 8, No. 1 (1/83), pp. 166-182.

# CHAPTER 11: REVIEW OF SPECIFIC MICROCOMPUTER HARDWARE FOR NATIONAL STATISTICAL OFFICES

The previous chapter discussed characteristics of specific microcomputer software. Operating systems, language processors, utilities, and application packages were discussed and insights were given. This chapter looks at specific microcomputer hardware. As background material, the reader is given some general characteristics of 8-bit and 16-bit systems; some thoughts on hardware trends; an overview of single-user, multiuser, and networked systems; and a discussion of overseas representation. The ideal hardware components of a microcomputer system are suggested. Finally, descriptions and opinions of specific microcomputer systems are given.

There are many factors which need to be considered when selecting microcomputer equipment. These factors are discussed in detail in the chapter entitled "Criteria for Microcomputer Selection." Stated briefly, a needs assessment is performed to determine how the system is to be used. Then available packaged software is evaluated for its potential to meet those needs. If packaged software cannot meet the defined needs, then development of custom software will be necessary. The hardware is selected first on its ability to support the required software. Factors that affect hardware selection include among others:

-- In-country support and maintenance for equipment;
-- Quality of documentation;
-- Quality and reliability of equipment;
-- Expandability and upgradeability of system; and
-- Ergonomic features of the system.

When there is no in-house experience with microcomputers, it is recommended that a consultant be hired to assist in the microcomputer selection process. As will be shown in this chapter, there are many important decisions that will need to be made during the selection process and experience with the equipment is a tremendous asset.

## 11.1 8-bit vs. 16-bit Systems

The major division in the marketplace is between proponents of 8-bit and 16-bit systems. Prior to 1981, few 16-bit personal computers existed. Advances in semiconductor technology permitted a reduction in price and affordable 16-bit personal computers began appearing. Most 8-bit systems are built around the Zilog Z80 and the MOS Technology 6502 CPU's. The majority of 16-bit systems are built around the 68000 and the Intel 8086/8088 family of CPU's.(1) Two of the most popular 8-bit operating systems are CP/M and Apple DOS. The most popular 16-bit operating systems are MS-DOS and CP/M-86, but UNIX and UNIX-like systems are increasing in number. The proponents of the 8-bit systems say that there is no reason to purchase a more expensive 16-bit microcomputer since the 16-bit machines do not currently have a large repertoire of

software and their additional capabilities are really unnecessary. The proponents of 16-bit machines say that the 8-bit machines have serious limitations, primarily in areas of speed and addressability.

The 8-bit machines do have some serious limitations. One measure of computing power is the number of bits on which the CPU can operate on at one time.(2) As the name implies, 8-bit machines can only transfer 8 bits of data at one time. Most 8-bit CPU's such as the 6502, 6800, 8085, and Z80 can directly address only 64KB of memory.(3) The operating system, the program, graphics, and data must all be stored within a single 64KB memory space. This can cause problems. Programs are often written in a form that is difficult to maintain in order to keep them small. The end-user interface is often compromised to save memory.(4) Many of the shortcuts taken to save code result in the software becoming less portable to other systems.

On the other hand, the 8-bit machines do have some advantages over 16-bit machines. They have been around longer than the 16-bit machines. More software is available for 8-bit machines than for the 16-bit systems, and in many cases this software has been more fully tested and debugged than software for the 16-bits. The more established 8-bit machines have been interfaced to more devices than the newer 16-bit machines. For many applications such as word processing and simple data entry, there is no need for large amounts of memory. The 8-bit machines as a general rule are less expensive than the 16-bit machines, and for many applications the 64KB memory limitation is not a critical factor.

The 16-bit machines are newer than the 8-bit machines. As mentioned earlier, fewer 16-bit personal computers existed prior to 1981. Since they employ a newer technology, the prices for 16-bit machines tends to be higher than those for 8-bit machines. The software for these machines is relatively new and less tested than that for 8-bit machines. Although the 16-bit machines are faster than the 8-bit machines, some of the software does not take full advantage of the speed potential. Processing speed is a function of the machine speed and software efficiency. Many device interfaces do not exist for some of the 16-bit machines. When a machine is to be interfaced to a new device such as a hard disk, a disk controller board is needed. Software patches must also be incorporated into the operating system and/or applications software programs to recognize the new device. As an example, CORVUS offers a hard disk interface and software patch for CP/M. At the date of this writing, CORVUS has no interface for MP/M 8-16, a multiuser 16-bit operating system. As time passes, the 16-bit systems will become as well established as 8-bit systems are now, and eventually exceed them, but at the present, 16-bit machines are lagging behind the 8-bit machines in some areas.

The main advantage of 16-bit microcomputers is their increased address space.(5) Actually the increased speed does not become a serious factor in most applications since the peripheral speed is usually the most constraining factor on overall system speed.

However, the increased address space of 16-bit systems, ranging from 1MB to 16MB of directly addressable memory, allows the development of more complex software on 16-bit machines than on 8-bit systems. Software can be developed with better end-user interfaces, making the systems more user-friendly. The software can be written in a more maintainable and portable format since writing compact code is not as critical a consideration. The operating systems can be written to be more user-friendly. They can even run faster since it is possible to have more of the operating system resident in memory at one time. It is easier to accommodate multiple users with the larger memory space available.(6) The 16-bit machines have a better potential for high resolution graphics than the 8-bit machines since increased resolution requires greater memory.

Figure 1 gives a summary of the characteristics generally associated with 8-bit and 16-bit microcomputers:

Figure 1: 8-bit versus 16-bit Comparison Summary

8-bit system

Advantages

-- 8-bit systems utilize an established and proven technology.
-- There is an abundance of software available and it has often been tested and debugged more thoroughly.
-- They can be interfaced to a variety of peripherals.
-- Microprocessors and systems are inexpensive.
-- Memory size is adequate for many applications.

Disadvantages

-- Only 64KB of memory are directly addressable.
-- Software written for systems tends to be less readable and portable due to shortcuts taken to save memory.
-- Applications requiring large amounts of memory cannot be done easily.
-- Resolution of graphics cannot be as high as in 16-bit systems due to memory constraints.
-- Operating systems and software are compromised in user-friendliness and speed to save memory.
-- The microprocessor is not designed for multiuser environments.
-- 8-bit systems are generally not as fast as 16-bit systems.
-- 8-bit systems can only perform arithmetic on 8- and 16-bit binary values. Other methods of computation can be much slower.

16-bit system

| Advantages | Disadvantages |
|---|---|
| -- Between 1MB and 16MB RAM of memory are directly addressable. | -- 16-bit systems utilize a newer technology. The equipment tends to be more expensive than 8-bit systems. |
| -- 16-bit systems are often faster than 8-bit systems. | -- Software is newer and less proven than software on 8-bit systems. |
| -- Some 16-bit microprocessors are designed for multiuser environments. | -- Many 16-bit operating systems and software packages are conversions of 8-bit software and do not take advantage of the capabilities of the 16-bit machines. |
| -- Software can be written in a more readable and portable fashion since memory is not as critical a concern. A significant amount of mainframe high-level language software can run directly on these machines. | -- Most multiuser operating systems are not very sophisticated. Error recovery and prioritizing of tasks tends to be weak. |
| -- User interfaces can be more user-friendly than on 8-bit systems. | -- Many 16-bit systems are not yet interfaced to many popular peripherals. |
| -- Some 16-bit microprocessors can perform 32-bit binary arithmetic. | |
| -- Graphics can have much higher resolution than on 8-bit systems. | |

The advantages and disadvantages of 8-bit and 16-bit microcomputers must be viewed in light of the applications for which they are intended. For example, the availability of a particular software package on an 8-bit machine may offset any limitations of speed and addressability. On the other hand, a large customized program might have to be heavily segmented to run on an 8-bit system, whereas it would fit nicely on a 16-bit system. There can be no uniform recommendation for 8-bit or 16-bit microcomputer systems; but rather a decision must take into account the intended use of the system and the associated system requirements.

## 11.2 Hardware Trends

It appears to be just a matter of time before the 16-bit microcomputers replace most 8-bit machines. The cost of these machines will keep falling, making the 16-bit systems more affordable. As more and better peripherals and software appear, more applications will be moved to 16-bit machines. The 8-bit systems with their low cost and wealth of software will remain a cost efficient tool for applications not requiring high computation speed or large memory space. Some vendors such as DEC, North Star, WANG, and CompuPro are preparing for the transition from 8-bit to 16-bit machines by offering dual processor 8/16-bit systems. Eventually the move will be to 32-bit computers. The 32-bit microprocessors are on their way. Both Motorola and Intel have

announced plans to develop true 32-bit microprocessors. Both claim that software currently running on their 16-bit microprocessors will be upward compatible to the 32-bit microprocessors. The Motorola 68000 microprocessor moves data on a 16-bit bus but processes data internally as 32 bits.(7) Intel's 80286 also moves data on a 16-bit bus and processes data internally as 32 bits. Software operating on 8086 and 8088 based systems will transfer to the 80286 without modification. Plans are for the Motorola 68000 and Intel 80286 to be replaced by compatible true 32-bit microprocessors. This planned compatibility of 16-bit and 32-bit machines should make the transition easier than that from 8-bit to 16-bit machines.

## 11.3 Single-User, Multiuser and Networked Systems

Single-user systems are the most popular type of microcomputer system. Single-user microcomputer configurations can be purchased at prices that are now quite affordable. Many applications do not require expensive configurations. The one-person, one-machine fantasy that was only a dream 10 years ago has become a reality.

Multiuser systems are becoming more available for both 8-bit and 16-bit microcomputers, but the industry is split on the relative merits of multiuser microcomputers. Multiuser systems allow the sharing of expensive resources and common data bases. Multiuser microcomputer systems suffer from system degradation (a slowing of response to users) when too much demand is placed upon the system.(8) Some 8-bit multiuser systems such as MP/M may significantly degrade with as few as two users. Most 8-bit microprocessors were designed to be single-user, single-tasking. The slower clock speed of the 8-bit microprocessors also contributes to system degradation. The 16-bit systems are somewhat better. Their capability of addressing larger amounts of memory, and the faster clock speeds make the 16-bit machines better for multiuser systems. However, many 16-bit microcomputers still suffer considerable system degradation with only three or four users. Assigning priorities to tasks that have different execution speeds requires a sophisticated microprocessor and operating system.(9) At present the level of sophistication of the multiuser operating systems for microcomputers is not as high as that of minicomputer and mainframe multiuser operating systems. Some of the multiuser microcomputer systems do not provide adequate protection and recovery when errors occur. This means that one user can accidently bring down the operating system, disrupting the work of other users. Multiuser systems are not as fast or reliable on microcomputers as they are on the mini- and mainframe computers.

Incorporating microcomputers into networks appears to be growing in popularity. Personal Computer Networks (PCN's), which are interconnections of small numbers of microcomputers for the purposes of data and peripheral sharing and information transfer, are the most prevalent form of network. PCN's are a proper subset of the more general classification of Local Area Networks (LAN's). A Strategic Inc. (San Jose, California) market-impact study

observes that through 1982, 12,000 PCN's have been installed.(10) The study also predicts that by 1987 there will be 110,000 PCN's.(11) Other types of networks such as Ethernet are also available for some microcomputers but are less popular than PCN's. This is probably true since most users have simple needs, using networks primarily for sharing expensive peripherals and do not need many of the features available from the more expensive networking systems. PCN's allow users to employ their microcomputer systems as single-user systems or as part of the network as desired.(12)

## 11.4 Overseas Representation

Overseas representation for microcomputer equipment sales, support, and maintenance varies dramatically among the microcomputer vendors. Some vendors have no overseas representation at all. Others have no corporate offices overseas, requiring the end-user to either deal through independent retail dealerships or with the main office. While both Apple and Radio Shack are well marketed overseas, Apple relies heavily on independent retail dealerships to provide user sales and support, while Radio Shack has its own outlets overseas. The effect is essentially the same, although Radio Shack probably has greater control over its own outlets. Some vendors will sell overseas, but offer no overseas service for equipment.

The heaviest concentration of outlets for microcomputers manufactured in the United States is in Europe. Alpha Micro, Altos, Charles River Data Systems, Columbia Data Products, Hewlett-Packard, Texas Instruments, and Zilog are among those represented in Europe. United States firms are not as well represented in Africa and South America. Alpha Micro is well represented in South America with dealer/service locations in Columbia, Dominican Republic, Ecuador, El Salvador, Puerto Rico, Uruguay, and Venezuela. Texas Instruments and Hewlett-Packard are also represented in South America, Asia, and Africa with sales and service locations or authorized dealerships located throughout those continents.

Although sales outlets for equipment may be in-country, this does not necessarily mean that in-country maintenance and support for the equipment are also available. The representation may only serve as a means of selling equipment. Support may only be available from a central office. When maintenance is required, the equipment may have to be shipped to an authorized repair center. Some vendors specify in their contracts that repair of equipment by unauthorized parties will void the warranty. It is important to determine whether the in-country representative also offers in-country maintenance and support.

Vendors such as IBM, DEC, NCR, Burroughs, Data General, and WANG have added microcomputers to their already existing lines of minicomputer and mainframe computers. As these vendors introduce microcomputers into the product lines of their overseas offices,

users should find an already well-established network of support and service available.

Several factors regarding local versus out-of-country representation must be taken into consideration when purchasing a microcomputer. The technical skills of local representatives vary widely. In some cases, local representatives have failed in repairing equipment and have even caused additional damage to the equipment. Some local representatives will refuse to provide maintenance for equipment not purchased through their company.

Some countries will not allow the products of certain vendors to enter the country or will assess taxes on equipment of 50% to 60% of the original price.(13) Countries that are close in proximity may not do business with each other for political reasons. The local representation and the country's policies in regard to a specific vendor's equipment must be evaluated on a case-by-case basis.

## 11.5 Review of Specific Hardware for Statistical Data Processing

This section will discuss microcomputer systems that could be used for applications within an NSO. In the discussion of overseas representation, it should have become apparent that selection of the appropriate equipment is often heavily dependent upon factors that have no relationship to the quality of a system's hardware and software. These considerations include:

-- Availability and quality of sales, support, and maintenance for the equipment.

-- Customs restrictions on the import of a specific vendor's products.

-- Restrictions on commerce between the country selling the equipment and the purchasing country.

-- Duties assessed on equipment brought into the country.

Given these restrictions, there is no one microcomputer system that could be recommended in every case, even for a specific application. The ensuing discussion focuses on ideal components of microcomputer systems. Following that are descriptions of specific microcomputer systems, indicating their strengths and weaknesses.

### 11.5.1 Ideal Components of a Microcomputer System

In the process of selecting a microcomputer system for a specific application, there are many factors which must be considered. Availability of the appropriate software for the application is probably the most important consideration. The price, support, and service are also important. Good documentation is essential.

This section will describe hardware components that are "ideal" in that they represent the best microcomputer technology available.

They are represented as being components of a microcomputer system; however, the system is purely fictitious. No needs assessment has been made for this equipment, and the system has no intended application. It is also possible that some of the components defined are incompatible with one another. The purpose of this description of an ideal machine is to identify desirable components of a microcomputer system.

In this example it is assumed that all the above selection criteria have been satisfied. Since microcomputer technology is changing rapidly, assume that selection of the hardware was made in March 1983. In a very short time, this system may be outdated. This section defines the characteristics of the "ideal" components of this system.

11.5.1.1 Motorola 68000 Microprocessor Board

The Motorola 68000 is the CPU around which our ideal system will be built. Although it is a 16-bit microprocessor, it has many of the same internal features as a 32-bit processor.(14) The Motorola 68000 can directly address 16MB of memory, the same as many IBM mainframes, and has outperformed the Intel 8086/8088 and Zilog Z8000 microprocessors in benchmark tests.(15)

11.5.1.2 S-100 Bus Chassis

The S-100 Bus (IEEE-696 Standard) has become a *de facto* standard for microcomputers.(16) Introduced on the Altair microcomputer in 1975, the S-100's popularity has grown. Today, a majority of the low-cost peripheral manufacturers produce devices directly compatible with the S-100. A system based on an S-100 bus is upgradeable. As new technologies appear, vendors will make those technologies available on S-100 compatible boards. For example, if a microprocessor becomes available on an S-100 board that is better than the Motorola 68000, it is possible (although not necessarily that simple) to replace the old microprocessor board with the new board. The constant voltage S-100 chassis has 20 slots available for boards and a built-in fan and power supply. A battery is also included to power the system clock.

11.5.1.3 Static RAM

The ideal system contains 1MB of static RAM contained in 2 - 512KB boards. Each board contains 72 - 64KB chips (parity bits included). Since this system will not offer a multiuser capability, 1MB RAM was considered adequate. Static RAM was selected over dynamic RAM since the additional complexity of refresh circuitry for dynamic RAM often reduces reliability.(17) ECC for correcting errors is also on the board.

11.5.1.4 Interface Boards

The system has a board with two RS-232C handshaking serial ports and a Centronics parallel port. The terminal will be connected to one serial port, and a printer will be connected to the parallel

port. The ports will have adjustable baud rates from 110 to 19.2K baud.

11.5.1.5 Communications Board with Modem

The system has a communications capability using the telephone network as the transmission system. The board offers the hardware capability for auto dial and auto answer. Baud rates, parity types, stop bits, and other features are software controlled.

11.5.1.6 High Resolution Color Graphics Board

A high resolution graphics capability is available on the system. The graphics board has on-board memory and firmware freeing the Motorola 68000 microprocessor to perform other tasks. The graphics board offers 800 by 600 pixel color graphics and is easy to access through high level languages.

11.5.1.7 Dual 8" Floppy Disk Drives

The half-height 8" floppy disk drives were selected since a standard exists for 8" floppy disk format. The drives are frequency independent running internally on DC instead of AC. This means they will not be affected by fluctuations in AC power. Floppy disks can be created or read in any format from single-sided, single-density to double-sided, double-density. Up to 1.25MB of data can be stored on a disk. The interface board uses a DMA technique for transferring data.

11.5.1.8 Removable Winchester Cartridge Drive

This drive provides 10MB of on-line storage, of which 5 MB are always resident and 5MB are in the form of a removable cartridge. The drive offers built-in error detection and correction. Additional drives can be added to the system as needed. A removable cartridge Winchester can be used in place of a conventional Winchester and can even serve as its own backup.(18) The system comes with an S-100 controller board which provides high speed DMA access. Up to 8 drives can be controlled from this board. The transfer rate for the drive is 5M bits per second with track-to-track access time of 3 milliseconds.

11.5.1.9 Keyboard and Video Monitor

The ideal system uses an ergonomically designed terminal. The low-profile keyboard is detached from the screen and may be positioned to almost any comfortable position. The keyboard contains a full ASCII character set and the keys are in the same positions as those found on the IBM Selectric typewriter. The keys also have the same feel as an IBM Selectric. The keyclick sound is adjustable to the user's preference.

A numeric keypad is also on the keyboard. This keypad, in addition to the numbers 0-9 in calculator layout, contains the special

characters "+", "-", ".", and a backspace key. The keypad also has its own enter key.

The keyboard has 16 programmable function keys. By invoking options while in local or setup mode, the function keys can be set to standard defaults or to a special set of values for a selected task. The keyboard also has many special keys including keys for left, right, up, and down cursor movement; backspace; backtab; home; clear screen; scroll up and scroll down; and page up and page down.

As was true of the keyboard, the monitor is also ergonomically designed. The monitor is enclosed in an adjustable housing. It is lightweight and easy to move. The amber screen display is comfortable to the eye and easy to use. Screen brightness is adjustable. The screen displays 132 characters per line and 24 lines. The terminal has 16KB of memory for screen paging. Using the scroll up, scroll down, or page up and page down, information that was previously on the screen can be recalled. Baud rate for the terminal is adjustable from 110 to 19.2K baud.

11.5.1.10 Color Graphics Monitor

The color graphics monitor is a high resolution display that can display color images clearly. It is a high bandwidth monitor, with a separate input for red, green, and blue (RGB). There is no noticeable flicker since the framing rate is high, operating at 38Hz.(19)

11.5.1.11 Printer

The dot matrix impact printer is a desktop model. It has a 15" carriage, allowing the use of standard computer printer paper. Paper may be either pin or friction fed. The printer operates at 200 characters per second and has a 16KB printer buffer. A controller board provides graphics capability, making it possible to print the image from the graphics monitor with one simple instruction. Pitch, line spacing, and character sets may be selected through software. The printer uses cartridge ribbons.

11.5.1.12 Network Controller Board

This board provides the control for such applications as file and printer sharing and electronic mail with other computer systems. Hardware and software can be combined to build configurations from a local network to a complete networking system covering large distances.(20) This network controller board allows the microcomputer system to gain access to networked resources such as high-speed or letter quality printers or 9-track IBM compatible tape drives that are part of the network since the network contains an IBM 4341 as one of its nodes. Since the network provides this microcomputer with access to these more expensive peripherals, it is not necessary to include these peripherals as part of the microcomputer system.

### 11.5.1.13 Power Supply

The UPS consists of a gasoline powered backup generator, a battery, a battery charger, and a DC to AC inverter. The computer system runs off the battery which is connected to the microcomputer through a DC to AC inverter. By running off the battery and not a wall plug, a buffer is provided between the potentially destructive transients, spikes, noise, and high/low perils found when connecting the computer directly to a wall plug. The battery charger serves only to recharge the battery and is itself powered from a wall plug. If there is a power failure, the battery can still operate the computer system for at least 1 hour. If the power failure is longer than one hour, the battery charger can be plugged into the gasoline powered generator.

### 11.5.1.14 Final Thoughts on the "Ideal" Components of a Microcomputer System

The components described above might be considered the best components available today. The descriptions are based on characteristics of components that exist today; however, some of the components may not yet be implemented on S-100 compatible boards or may not be compatible with other components in the system. The purpose of this discussion was to identify optimal characteristics of the individual components that collectively comprise a system.

### 11.5.2 Vendor Specifics

In this section, specific characteristics of a select set of microcomputers are discussed. The microcomputer systems are listed in alphabetical order within microprocessor type. Strengths and weaknesses of each system are presented. The descriptions, advantages, disadvantages, and languages of each system are based on a combination of ISPC's literature search, hands-on experience, and conversations with vendors and system users. The international marketing information was obtained from conversations with vendors and from literature received.

Some systems described in this section were selected as representative examples of systems based on certain microprocessors; others were selected for having special characteristics such as low price, built-in networking capability or strong international marketing. The listing of a microcomputer system by no means implies that it is being recommended for use in NSO's.

### 11.5.2.1 MOS Technology 6502

MOS Technology manufactured the MOS Technology 6502 microprocessor to be a direct competitor of another 8-bit microprocessor, the Motorola 6800.(21) As is true of most 8-bit microprocessors, the MOS Technology 6502 can directly access 64KB of RAM. It has an 8-bit bus and 8-bit registers. The MOS Tech 6502 is very low priced, which results in its being in use in inexpensive, small to

medium-sized systems. MOS Technology was acquired in 1978 by Commodore International.

System Name: Apple IIe

Manufacturer: Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014

Telephone: (408)-996-1010

Price: $1995

Includes: Hardware -- Apple IIe System main unit with 64KB RAM, Disk II and controller, Monitor III, Monitor stand, and 80-column text card.
Software -- DOS 3.3.

Description:

The Apple IIe is the successor to the very popular Apple II+. Although the Apple IIe is physically a complete redesign of the Apple II+, it is compatible with almost all existing Apple II software and hardware add-ons.(22) In a survey of microcomputer users undertaken by ISPC, it was found that over one-third of the questionnaires returned indicated use of an Apple microcomputer.

The Apple IIe uses as its microprocessor the MOS Technology 6502 CPU. It comes standard with a full 64KB RAM. Color graphics is a standard feature of the system, if a color monitor is available. Audio is also a standard feature. Operating systems available include Apple DOS, Apple Pascal, and CP/M; the latter requiring a special CPU board.

Languages:

-- BASIC
-- Assembly
-- FORTRAN
-- Pascal
-- Pilot
-- LOGO
-- many other languages available under CP/M

Advantages:

-- The system is low priced.

-- There is a wealth of software available.

-- The system supports up to 6 floppy disk drives.

-- CP/M, DOS 3.3, and UCSD Pascal operating systems are available.

-- Documentation is good.

-- There is a good distribution network for the equipment.

-- There are many user groups.

-- Many peripherals and interfaces are available.

-- Color graphics capability is a standard feature (if a color monitor is available).

-- Construction of the equipment is rugged.

Disadvantages:

-- The system can only directly access 64KB of memory.

-- The floppy disks can only hold 140KB of data.

-- There is no parity checking of RAM. Dynamic RAM instead of static RAM is used.

-- 5-1/4" floppy disks are not in a standard format. In fact, floppy disks formatted under one of its operating systems cannot be read by any other of its operating systems without using a special utility.

-- A numeric keypad is an add-on feature.

-- VisiCalc spreadsheet software will not run on a system with a CORVUS hard disk attached.

-- DOS 3.3 has a weak text editor. If software development is to be done in BASIC, a good text editor should be purchased.

International Marketing:

Apple has authorized dealers or distributors in Antigua, Argentina, Australia, Bahrain, Bangladesh, Bermuda, Bolivia, Brunei, Cayman Islands, Chile, Colombia, Dominican Republic, Ecuador, Egypt, Fiji, Guam, Guatemala, Hong Kong, India, Indonesia, Ivory Coast, Jamaica, Japan, Jordan, Kenya, Korea, Kuwait, Lebanon, Malaysia, Marshall Islands, Mauritius, Mexico, Morocco, Nepal, Netherland Antilles, New Caledonia, New Guinea, New Zealand, Nigeria, Oman, Pakistan, Panama, Peru, Philippines, Puerto Rico, Qatar, Samoa, Saudi Arabia, Singapore, Solomon Islands, South Africa, Sri Lanka, Surinam, Syria, Tahiti, Taiwan, Thailand, Trinidad, Tunisia, United Arab Emirates, Uruguay, Vanuatu, Venezuela, Virgin Islands, and Zaire. Apple relies heavily on authorized dealerships to sell and support its equipment.

System Name: Atari 800

Manufacturer: Atari, Inc.
Home Computer Division
1312 Crossman
P.O. Box 61657
Sunnyvale, CA 94086

Telephone: (408)-942-6500

Price: $1675

Includes: Hardware -- 48KB RAM, disk drive, 80-column printer, interface module, cables.
Software -- operating system, BASIC.

Desription:

The Atari 800 is generally considered a home computer. However, it is also capable of handling small and professional applications.(23) Many educational institutions use Atari computers as educational tools. The system is based upon the MOS Technology 6502 CPU. Memory can be expanded to 48KB RAM.

Languages:

-- BASIC
-- Assembler
-- Pilot

Advantages:

-- The system is low priced.

-- Communications capability is available.

-- The system has a high resolution color graphics capability.

-- A wealth of educational software is available.

Disadvantages:

-- Memory is only expandable to 48KB RAM.

-- The operating system is not standard.

-- Diskette capacity of 88KB is inadequate for many applications.

-- Only BASIC, Assembler, and PILOT are available as programming languages.

-- Range of usuable peripherals is limited.

### 11.5.2.2 Zilog Z80

Three of the designers of the 8080 microprocessor left Intel and created a company named Zilog.(24) Its first product was the Z80 which was designed to be upward compatible with the Intel 8080 with some additional capabilities. The Z80 is the most popular 8-bit microprocessor today. Approximately 39% of the microcomputer models being offered for sale today use the Z80 microprocessor for its CPU. The Z80 has an 8-bit bus and 8-bit registers. As is true of most 8-bit microprocessors, the Z80 can directly access up to 64KB RAM. The Z80A is a faster version of the original Z80.

System Name: ACS 8000

Manufacturer: Altos Computer Systems
2360 Bering Drive
San Jose, CA 95131

Telephone: (408)-946-6700

Price: $4990

Includes: Hardware -- CPU, 208KB RAM, 2 disk drives, parallel port, 6 RS-232C serial ports.

Description:

Altos Computer Systems markets sytems primarily for business, graphics, and scientific applications. They sell microprocessor systems based on the Zilog Z80A, the Intel 8086, and the Motorola 68000. The ACS 8000 is based on the Z80A microprocessor. This hardware can handle up to 4 users. The two floppy disk drives provide an on-line 1MB or optional 2MB total storage capacity. The system can be upgraded with a hard disk. The MP/M, CP/M, and OASIS operating systems are available along with a large selection of compilers and software packages.

Languages:

- -- BASIC
- -- FORTRAN
- -- COBOL
- -- Pascal
- -- APL
- -- PL/I
- -- Assembler
- -- Other languages are available under CP/M

Advantages:

- -- The system uses the very popular Z80A microprocessor, and offers a good selection of operating systems including CP/M and OASIS.

-- The U.N. has on several occasions recommended the ACS 8000 for use in statistical data processing in developing countries.

-- The system offers a multiuser capability.

-- Standard 8" floppy disk drives are used in the system.

-- A hard disk offering 40MB of storage can be attached.

Disadvantages:

-- The Z80A only allows each user to directly address 64KB RAM.

-- The system uses a non-standard bus.

International Marketing:

Altos Computers has distributors in Argentina, Australia, Bermuda, Brazil, the Caribbean, Colombia, Hong Kong, Indonesia, Mexico, New Zealand, Pakistan, Puerto Rico, Peru, the Philippines, Saudi Arabia, Singapore, South Africa, South Korea, Suriname, Taiwan, and Venezuela.

System Name: Kaypro II

Manufacturer: Kaypro
Division of Non-Linear Systems, Inc.
533 Stevens Avenue
Solana Beach, CA 92075

Telephone: (619)-755-1134

Price: $1795

Includes: Hardware -- 64KB RAM, 2 disk drives, 9' CRT, keyboard, RS-232C and Centronics parallel interfaces.
Software -- CP/M, SBASIC, Profitplan, Perfect Writer, Perfect Calc, Perfect Speller, and Perfect Filer.

Description:

The Kaypro II is designed to directly compete with the Osborne I. Originally called the Kaycomp II, the Kaypro II is a portable 26 pound Z80A based microcomputer. It features a 9" diagonal screen, 2-200KB disk drives, and a keyboard with a numeric keypad as part of the portable unit. It is designed for use in many straightforward applications and, as is also true of the Osborne I, is designed for use by businessmen and families.

Languages:

-- SBASIC
-- MBASIC
-- Assembler
-- Other languages are available under CP/M

Advantages:

-- The system is inexpensive, comparable in price and value to the Osborne I.

-- The system is portable, weighing 26 pounds.

-- It runs CP/M, a portable operating system.

-- A numeric keypad is a standard feature.

-- The screen is 9" diagonal with 80 X 24 characters compared to 5" with 52 X 24 characters for the Osborne I.

-- Disk drives come standard at double density (approximately twice the storage capacity of the Osborne).

-- The metal casing is rugged.

-- The system is capable of reading disks prepared in XEROX 820 Format.(25)

-- The Kaypro 5 includes one floppy disk and one 5.5MB Winchester hard disk.

Disadvantages:

-- The Z80A can only directly access 64KB RAM.

-- There is no switch to allow conversion from 110 to 220 AC as exists on the Osborne I.

-- No parity checking on RAM is implemented.

-- The software that comes standard on the Kaypro is less popular or less well known than that on the Osborne I.

-- The system contains a non-standard bus.

-- Expandability is limited.

-- Graphics capability is not included.

International Marketing:

Kaypro has distributors in Argentina, Australia, Belgium, Canada, China, Columbia, Denmark, Finland, West Germany, Greece, Haiti, Hong Kong, Iceland, India, Israel, Italy, Ivory Coast, Korea,

Lebanon, Malaysia, Mexico, Netherlands, Netherland Antilles, New Zealand, Nigeria, Norway, Pakistan, Panama, Peru, Philippines, Puerto Rico, Qatar, Saudi Arabia, Singapore, South Africa, Spain, Switzerland, Thailand, Togo, Turkey, United Kingdom, Venezuela, and the West Indies.

System Name: North Star Horizon

Manufacturer: North Star Computers, Inc.
14440 Catalina Street
San Leandro, CA 94577

Telephone: (415)-357-8500

Price: $3599

Includes: Hardware -- 64KB RAM, 12 slot S-100 chassis, 2 disk drives.
Software -- DOS operating system, BASIC.

Description:

The North Star Horizon is one of the more popular 8-bit Z80 based microcomputers on the market today. It uses the industry standard S-100 bus and comes available in a variety of configurations with a selection of different operating systems and software. In benchmark tests made, the Horizon performed well against more expensive competitors.(26) Users feel the hardware is reliable and reported good service.

Languages:

-- BASIC
-- COBOL
-- FORTRAN
-- Pascal
-- More compilers available under CP/M

Advantages:

-- The standard S-100 bus means more peripherals available and more interchangeability of parts. The 12 slots in the chassis provides room for expansion.

-- The manufacturer is a well established vendor of microcomputers.

-- The system has a rugged design.(27)

-- The system uses parity RAM.

-- Hard disk storage can be from 5MB to 72MB.

-- North Star DOS/HDOS, CP/M, and multiuser operating systems are available with a wide selection of software available for CP/M.

-- The system is relatively inexpensive when compared to other S-100 bus systems.

-- The system has been successfully used to process agricultural and economic survey data in developing countries by the U.S. Department of Agriculture.(28)

-- A wide variety of configurations are available including multiuser and hard disk versions.

Disadvantages:

-- The system uses 5-1/4" floppy disk drives instead of the more standard 8" floppy drives.

-- North Star has no plans to upgrade the North Star Horizon to have a 16-bit microprocessor, and currently the Horizon cannot be included in NorthNet, North Star's local area network for the North Star Advantage.

-- The Z80A allows each user a maximum of 64KB of directly addressable RAM.

-- Users of the multiuser systems report a noticeable speed degradation with 3 or more users.

International Marketing:

North Star has distributors in Australia, Canada, Carribean, Europe, Hong Kong, Malaysia, the Middle East, South Africa, and South America.

<u>System Name</u>: Osborne I

Manufacturer: Osborne Computer Corporation
26500 Corporate Avenue
Hayward, CA 94545

Telephone: (415)-887-8080

Price: $1795

Includes: Hardware -- 64KB RAM, 2 disk drives, 5" monitor, keyboard, RS-232C and IEEE-488 interfaces.
Software -- CP/M, WordStar, SuperCalc, CBASIC, and MBASIC.

Description:

The Osborne I, the brainchild of Adam Osborne, is a portable microcomputer system designed to perform a number of

straightforward tasks, using industry standard operating systems and software.(29) It is designed for use by managers for correspondence, planning, and organization; however, it can be used for many other applications.

The system uses the Z80A, a 4MHz microprocessor as its CPU. Contained in the portable 24 pound unit are a keyboard, a 5" green screen, 2-100KB disk drives, a CPU, 64KB RAM, and serial and parallel interfaces.

Osborne has just recently announced the Osborne Executive. This computer looks very similar to the Osborne I and is still based on the Z80A microprocessor, but features a 7" amber display, 2 half-height, double-density disk drives, 128KB RAM, 2 serial ports and a parallel port. It also has a special internal connector so the machine can eventually be upgraded with an 8088 processor to run MS-DOS.(30)

Languages:

-- CBASIC
-- MBASIC
-- Pascal
-- Assembler
-- Many more languages are available under CP/M

Advantages:

-- The system is inexpensive. The software alone, if purchased separately, would cost almost as much as the entire system.

-- The system is portable and contained in a durable housing.

-- A built-in switch allows conversion from 110AC/60Hz to 220AC/50Hz.

-- It runs CP/M and UCSD p-System operating systems and software.

-- A numeric keypad is a standard feature on the keyboard.

Disadvantages:

-- The 5" screen is too small. An optional screen should be added to the system for any serious processing.

-- The 100KB capacity of the diskettes is not adequate for many applications. Users may need to upgrade the disk drives.

-- The Z80A can only directly access 64KB RAM.

-- Only 52 characters per line can be displayed on the standard Osborne I, but this can be upgraded.

-- There is no parity checking of RAM.

-- A graphics capability is not included.

-- Expandability of the system is limited and difficult. Space for additional boards is nonexistant and the system uses its own proprietary bus.

International Marketing:

Osborne has authorized dealerships in American Somoa, Argentina, Australia, Belgium, Chile, Colombia, Denmark, Finland, France, Germany, Greece, Guatemala, Hong Kong, Iceland, India, Indonesia, Israel, Italy, Kenya, Malta, Netherlands, Netherland Antilles, New Zealand, Norway, Panama, Peru, Philippines, Portugal, Puerto Rico, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, and Venezuela.

11.5.2.3 Motorola 6809

The Motorola 6809 is the successor to the Motorola 6800. It is an 8-bit microprocessor designed for high performance and is considered by many technicians to be the best 8-bit microprocessor around. The 6800 instruction set is compatible with the 6809, and 6800 programs can be easily adapted to the 6809. The Motorola 6809 uses 16-bit internal instructions but communicates with the outside world with an 8-bit bus.(31) Although the 6809 has proven excellence in benchmark tests of speed, it is nowhere near as popular as the Z80 and 6502 microprocessors. This is probably due to the late arrival of the 6809 when compared to the first deliveries of the Z80 and 6502 microprocessors. Smoke Signal, Southwest Technical Products (SWTP), and Canon offer microcomputer systems based on the Motorola 6809.

System Name: Smoke Signal Chieftain 9822

Manufacturer: Smoke Signal Broadcasting
31336 Via Colinas
Westlake Village, CA 91362

Telephone: (213)-889-9340

Price: $8149

Includes: Hardware -- Processor, 64KB RAM, CRT, keyboard, printer, 2 floppy disk drives.
Software -- DOS 69 operating system, BASIC.

Description:

The Chieftain 9822 is based on the Motorola 6809, an 8-bit microprocessor that shows outstanding performance when compared to Z80A and 6502 microprocessors. In benchmarks, a Chieftain 9822 using floppy disks outperformed many more expensive Z80A based systems, and in one case, came very close to the time set by a Z80A

based system that was using a Winchester hard disk.(32) Unfortunately there does not appear to be much packaged software available for the system.

Languages:

- BASIC
- COBOL
- Assembler
- Pascal
- FORTRAN
- Forth

Advantages:

- The system is based on a high-performance 8-bit microprocessor.
- Single and multiuser configurations are available.
- The OS-9 multiuser operating system is "UNIX comparable."
- The system uses SS-50 bus with 9 main slots and 8 I/O slots in the chassis for expansion.
- RAM is expandable to 1MB.
- SMD or smart interface is available for the disk drive.
- Static RAM is used instead of less reliable dynamic RAM.

Disadvantages:

- Dealers tend to specialize in specific industry areas and therefore do not make much generalized software available. Smoke Signal's approach to software is to make all software development the responsibility of the dealer.(33)
- The microprocessor can directly access only 64KB RAM.
- The SS-50 bus is not very popular.

International Marketing:

Smoke Signal Broadcasting has a combination of authorized dealerships and OEM's located in Australia, Austria, Denmark, Greece, India, Italy, Netherlands, New Zealand, South Africa, Sweden, United Kingdom, and West Germany.

11.5.2.4 Intel 8086/8088 Series

The Intel 8086 was the first truly general-purpose 16-bit microprocessor. Many of the architectural features of the 8-bit 8080 were maintained in the 8086, but there was not an attempt to maintain upward compatibility.(34) The 8086 has 16-bit registers

and a 16-bit data bus. Using its segment registers, the 8086 can access over 1MB of memory. The 8088 is internally identical to the 8086, but communicates to external devices using an 8-bit data bus. Although the 8086 is not the fastest 16-bit microprocessor available, its early introduction and Intel's support have made it the most popular.

System Name: IBM Personal Computer

Manufacturer: IBM Corporation
Information Systems Division
Entry Business Systems
P.O. Box 1328
Boca Raton, FL

Telephone: (305)-998-6007

Price: $2104

Includes: Hardware -- 64KB RAM, keyboard, 1 disk drive, and adapter.
Software -- MS-DOS operating system, BASIC interpreter.

Description:

The IBM Personal Computer (PC) is the much-heralded release by the giant of the computer industry. Soon after IBM announced the PC on August 12, 1981, they were swamped with purchase request.(35) Many vendors quickly started selling add-ons and software for the PC. By September 1982, PC magazine produced a list itemizing over 1250 compatible products for the IBM PC.(36) Other firms have also released new microcomputer systems which they claim to be hardware and/or software compatible with the IBM PC.

Although the IBM PC may have revolutionized the microcomputer industry, the technology it uses is not very revolutionary. It is based on an Intel 8088 microprocessor and runs PC-DOS which is another name for MS-DOS, a CP/M lookalike.(37) PC-DOS does not allow the user to access the potential 1MB RAM. Many users have complained about the poor quality of the color graphics and the design faults inherent in the keyboard. In some benchmark tests, the IBM PC was not much faster than an Apple II.(38)

The IBM Personal Computer is a successful system and will continue to be for some time in the future. IBM provides good support for its equipment. It undoubtedly will correct many existing problems with the equipment and provide enhancements to improve the product. With IBM and other vendors selling IBM add-ons and software, there should be no problems with availability of anything for the IBM PC.

Languages:

- -- BASIC
- -- Pascal
- -- COBOL
- -- FORTRAN
- -- APL
- -- C
- -- Assembler

Advantages:

-- Documentation for the system is very good.

-- Good overseas representation and support channels for equipment are available. IBM has recently announced it intends to distribute the IBM PC overseas.

-- The system can run MS-DOS, CP/M-86, Concurrent CP/M-86, UCSD p-System, and Qunix (a multiuser UNIX-like operating system).

-- With a hardware add-on, the system can run CP/M software.

-- Color graphics capability is available.

-- A wealth of software is available. New software products are being announced regularly.

-- Two vendors, Tecmar and Genie Computer Corporations, are both offering removable cartridge hard disk systems for the PC.

-- Innovative Data Technology (IDT) offers a 9-track, IBM compatible tape drive for the PC.

-- Parity checking is done on RAM.

-- More than 640KB of RAM is directly addressable.

-- Quadram Corporation has announced Quadlink which is a board that can be added to the IBM PC to allow it to operate on Apple DOS 3.3 software.

Disadvantages:

-- The 5 slot chassis leaves little room for expansion.

-- Text displayed on the color monitor is not very legible.

-- IBM claims their graphics interface has a resolution too high to display properly on a regular monitor.(39) An RGB monitor is needed.

-- The keyboard has some keys out of place. The return and left shift keys are hard to find.

-- The system uses 5-1/4" floppy disk drives. The more standard 8" drives are available through other vendors.

-- The MS-DOS operating system does not take advantage of the full addressing capabilities of the Intel 8088 microprocessor.

-- The PC has been unimpressive in benchmarks. The PC's 8088 microprocessor with its 16-bit registers and 8-bit external data transfer is slow when compared to the Intel 8086 or the Motorola 68000 microprocessors.

-- Microsoft FORTRAN-77 is considered to not be a good compiler.

International Marketing:

IBM has authorized Personal Computer dealerships in Australia, Austria, Belgium, Bermuda, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Japan, Malaysia, Netherlands, New Zealand, Norway, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, and the United Kingdom.

System Name: IWS-1000

Manufacturer: Convergent Technologies
2500 Augustine Drive
Santa Clara, CA 95051

Telephone: (408)-727-8830

Price: $12,825

Includes: Hardware -- 128KB RAM, CPU, keyboard, CRT, 2 floppy disk drives, RS-232C, RS-422, or another RS-232C, Centronics interface, and 2 Multibus slots. Software -- CTOS operating system, editor, assembler, linker, librarian, spooler for print, asynchronous terminal emulator, and debugger.

Description:

Convergent Technologies was formed in 1979 by former executives of Intel and DEC. The company deals primarily through OEM's (Original Equipment Manufacturers). This means that they sell their equipment to other vendors that add value to the product and then market it under their own name. The IWS-1000 is marketed by NCR as the Worksaver, by M/A-Com Alanthus as the System 1000 and by Burroughs as the B20. The system is designed to compete with both microcomputers and minicomputers. One system can be purchased and used as a microcomputer, or several can be networked using

Convergent Technology's own local area network to provide the power of a minicomputer.

The system is built around the Intel 8086, but versions are available using the Intel 8088. CTOS, for Convergent Technology OS, is the operating system. It offers a user-friendly interface prompting the user for inputs. NCR is developing new language compilers to sell with the system, while M/A-Com Alanthus is emphasizing office systems applications. M/A-Com Alanthus is using the language compilers distributed by Convergent Technologies.

Languages:

-- COBOL
-- Assembler
-- BASIC
-- FORTRAN
-- Pascal

Advantages:

-- The System is good for applications where distributed processing is needed.

-- IEEE-796 standard Multibus slots are available for add-ons.

-- M/A-Com Alanthus offers a 9 track IBM compatible tape drive for the system.

-- M/A-Com Alanthus also offers a CP/M emulator on systems that have 8" floppy disks. This means that most CP/M software can run on the system.

-- The system runs MS-DOS and can read IBM PC disks using a utility.

-- The CTOS operating system is user-friendly and prompts the user for inputs. It provides a real time multitasking capability.

-- The CRT can display 132 X 34 characters.

-- Graphics capability is available.

-- NCR and Burroughs have offices overseas. Service and support should be generally available.

-- The system handles IBM 3270 protocol.

-- The system uses the more standard 8" floppy disk drives along with the 5-1/4" disk drives.

-- Parity RAM is used.

Disadvantages:

-- CTOS is not a portable operating system.

-- A limited number of compilers and application software is available under CTOS.

-- The GO key on the standard keyboard is used to execute a command instead of the RETURN key. This special key is not conveniently located on the keyboard.

-- There are no known users groups.

-- The FORTRAN and COBOL compilers are not highly rated.

-- The system is expensive.

International Marketing:

Convergent Technologies has authorized dealerships in Japan and the United Kingdom. M/A-Com Alanthus has no overseas representation. NCR has authorized distributors on all 7 continents. Burroughs has authorized distributors in Europe, Latin America, the Middle East, and Southeast Asia. Burroughs' major distributors are located in Finland, Greece, Iceland, Israel, Jordan, Korea, Lebanon, Singapore, and Saudi Arabia.

System Name: TeleVideo TS 1600 Series

Manufacturer: TeleVideo Systems, Inc.
1170 Morse Ave.
Sunnyvale, CA 94086

Telephone: (408)-745-7760

Price: $3,495

Includes: Hardware -- CPU, 128KB RAM, 2 floppy disk drives, keyboard, CRT, 2 RS232C serial ports, 1 RS422 port.
Software -- CP/M-86.

Description:

TeleVideo is probably better known for its terminals. In May 1981, TeleVideo introduced its first microcomputer. The TS1600 series is a family of new 16-bit microcomputers. The computers are designed as standalone systems that can be networked together to access common peripherals and software.

The TS 1600 machines use the Intel 8088 as their microprocessor. They have high-resolution screens (640 x 480 resolution is available) and run the CP/M-86 operating system.

Languages:

-- Runs CP/M-86 compilers and interpreters

Advantages:

-- A full standalone microcomputer can be purchased for less than $3,500.

-- The system runs CP/M-86, a standard operating system with a lot of software.

-- The system can be run in standalone or be networked to other TeleVideo machines.

-- Hard disk versions of the system are available.

-- Televideo's distribution network process is good.

-- The high-resolution CRT is good for graphics.

Disadvantages:

-- The system is very new.

-- The bus is non-standard.

-- The system cannot run CP/M.

-- Currently there is no communications support.

-- Televideo has a questionable reputation for hardware reliability.

International Marketing:

Televideo has international distributors in Argentina, Australia, Austria, Belgium, Chile, Columbia, Denmark, England, Finland, France, Greece, Holland, Hong Kong, Iceland, Indonesia, Ireland, Israel, Italy, Lebenon, Malaysia, Mexico, Netherlands, Nicosia, Norway, Pakistan, Panama, Peru, Philippines, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, Uruguay, Venezuela, West Germany, and the West Indies.

<u>System Name</u>: Victor 9000

Manufacturer: Victor Business Products
3900 North Rockwell St.
Chicago, IL 60618

Telephone: (408)-438-6680

Price: $4995

Includes: Hardware -- CPU, 128KB RAM, 2 floppy disk drives, CRT, keyboard, 2 serial I/O ports, 2 parallel ports. Software -- CP/M-86, MS-DOS.

Description:

Victor Business Products has been manufacturing calculators for 60 years and developed the Victor 9000 as a business computer. The system is based on the Intel 8088 microprocessor and comes standard with 2-600KB 5-1/4" disk drives. For storage, the Victor 9000 uses Group Code Recording (GCR), a technique of compressing data by squeezing out zeroes. There are never more than two zero s in a row.(40) The video monitor has a high resolution display that tilts and swivels. It should be noted that Ford Motor Company has selected the Victor 9000 as its standard single-user workstation and estimates that 1500 will be purchased by Ford over the next 3 years.(41) Graphics displayed on the Victor 9000 screen are impressive since at 800 by 400 pixels (picture elements), the resolution is much higher than can be achieved on the Apple II, III, or the IBM PC.

Languages:

-- BASIC
-- COBOL
-- FORTRAN
-- Pascal
-- Assembler

Advantages:

-- The system runs both MS-DOS and CP/M-86 software.

-- The system is bundled so there is less need for expensive add-ons.

-- Several correctly installed word processing, spreadsheet, and data base management packages are available directly from Victor.

-- The system has an excellent high resolution green screen monitor with 800 by 400 pixels for graphics.

-- The system is ergonomically designed with a screen that tilts and swivels. It has a selection of 3 detachable keyboards, and takes up a small amount of desktop space.

-- Group code recording (GCR), a special technique for squeezing out zeroes, compresses data before it is stored thus saving lots of disk space.

-- RAM is expandable to 896KB.

-- On a double sided 5-1/4" disk drive, 1.2MB of data can be stored.

-- Victorcalc is a three-dimensional spreadsheet, allowing paging in and out, and rotation of the three-dimensional cube to different perspectives.

Disadvantages:

-- The system uses 5-1/4" floppy disk drives instead of the more standard 8" drives. Their floppy disk drives are not compatible with any other systems' drives.

-- The FORTRAN compiler is Microsoft's implementation of FORTRAN-77; not considered a very good compiler.

-- The Victor 9000 is unimpressive in benchmarks. It performs comparably to the IBM PC, but a 4MHz Z80 performs better.(42)

-- Availability of peripherals from other vendors is not as high as for IBM PC.

-- Parity memory is an option.

International Marketing:

Victor Business Products has authorized distributors located in Africa, Asia, Australia, Europe, and the Middle East.

System Name: Wang Professional Computer

Manufacturer: Wang Laboratories, Inc.
One Industrial Avenue
Lowell, MA 01851

Telephone: (617)-459-5000

Price: $2695

Includes: Hardware -- CPU, 128KB RAM, 1 disk drive, keyboard, RS-232C port, parallel printer port.
Software -- MS/DOS, BASIC.

Description:

Originally founded in 1951, Wang Laboratories was one of the first companies to produce programmable calculators.(43) Their product line was expanded to include minicomputer-based small business systems and now includes microcomputers.

The Wang Professional Computer is intended for professionals and managers. It is based on the Intel 8086 microprocessor and comes standard with 128KB RAM and 1 - 320KB disk drive. Some of the software written for the IBM PC can run on the system. The system is ergonomically designed, with a lightweight and compact system enclosure, a low-profile keyboard and an optional monitor with a movable arm allowing adjustment to any comfortable position. Local

communications allows the Professional Computer to emulate Wang VS and Alliance workstations.(44)

Languages:

- -- BASIC
- -- COBOL
- -- Assembler
- -- Pascal
- -- FORTRAN

Advantages:

-- Wang has a good product distribution network.

-- The system has performed well in benchmark tests. It has been shown to run 2 - 3 times faster than the IBM PC in some tests.

-- It has an excellent ergonomic design.

-- It runs MS-DOS, the IBM PC operating system and some software will transfer from the IBM PC to the Wang Professional Computer.

-- It can emulate Wang VS and Alliance workstations. If a Wang VS or Alliance is already on hand, the Wang Professional Computer can serve both as a workstation or as a standalone microcomputer.

-- A hard disk is available for the system.

-- The Wang version of MS-DOS provides a menu interface.

Disadvantages:

-- The system is not totally IBM compatible. Not all of the IBM software will transfer or run on the system.

-- Very little software is currently available from Wang for the system.

International Marketing:

Wang has international offices located in Australia, Austria, Belgium, Canada, China, France, Great Britain, Hong Kong, Japan, the Netherlands, New Zealand, Panama, Puerto Rico, Singapore, Sweden, Switzerland, and West Germany. In addition to thier international offices, Wang supports disbributors in Argentina, Bahamas, Barbados, Bermuda, Bolivia, Botswana, Brazil, Cameroun, Canary Islands, Chile, Colombia, Costa Rica, Curacao, Cyprus, Denmark Dominican Republic, Ecuador, Egypt, Fiji, Finland, the Gambia, Ghana, Greece, Guam, Guatemala, Guinea, Honduras, Iceland, India, Indonesia, Ireland, Israel, Italy, Ivory Coast, Japan, Jordan, Kenya, Korea, Kuwait, Lebanon, Liberia, Malaysia, Malta,

Mauritius, Mexico, Morocco, New Guinea, Nigeria, Norway, Oman, Pakistan, Paraguay, Peru, the Philippines, Portugal, Qatar, Saudi Arabia, Senegal, Sierra Leone, South Africa, Spain, Sri Lanka, Sudan, Tanzania, Thailand, Trindad-Tobago, Turkey, United Arab Emirates, Uruguay, Venezuela, Yemen, Zaire, Zambia, and Zimbabwe.

11.5.2.5 Motorola 68000 Series

The Motorola 68000 was introduced after the Intel 8086 and the Zilog Z8000. It implements a pure speed approach and shows superior performance in most benchmarks against the other generally available 16-bit microprocessors. Vendors claim that the 68000 can reach 1 MIPS (millions of instructions per second). This is equivalent to the speed of a UNIVAC 1108, a mainframe computer manufactured in the late 1960's and early 1970's. The 68000 has a 16-bit data path and 32-bit registers. Integer arithmetic can be performed on 32-bit binary numbers on the Motorola 68000 as compared with arithmetic on 16-bit binary numbers on the Intel 8086. The 68000 can address 16MB of memory using a 24-bit address. This is equivalent to the direct addressing capability of an IBM 3031 mainframe computer. Of the three most popular 16-bit microprocessors, the Motorola 68000, the Intel 8086, and the Zilog Z8000, the Motorola 68000 is the closest to implementing the power of a mainframe on a microprocessor chip.

System Name: Apple Lisa

Manufacturer: Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014

Telephone: (408)-996-1010

Price: $9995

Includes: Hardware -- CPU, 1MB RAM, 2 floppy disk drives, hard disk, keyboard, CRT, 2 serial ports.
Software -- Lisa Draw, Lisa Write, Lisa Project, Lisa Calc, Lisa List, and Lisa Graph.

Description:

The Apple Lisa is the end-result of a project that cost over $50 million and took more than 200 person years to complete.(47) It is considered by many to be the most significant development in computers in the last five years. Lisa, which stands for Local Integrated Software Architecture, is designed for professionals, managers, and administrators in large organizations. The system is designed to be easy to learn by "computer illiterate" professionals.

Lisa uses the Motorola 68000 microprocessor. It comes standard with 1MB of RAM, 2-860KB 5-1/4" disk drives and a 5MB hard disk. Lisa has its own proprietary operating system.

Working on the Lisa is like working at a desk.(48) It lets the user do several jobs such as word processing, drawing, calculating, and project scheduling at once. The user tells Lisa what to do by using a device called a mouse to move a pointer to a command at the top of the screen. When that task is selected, a submenu is displayed and the user makes further selections.

Languages:

-- None currently available

Advantages:

-- The system is extremely user-friendly. It is designed for nontechnical users.

-- The system has a high resolution graphics capability with a screen resolution of 720 x 364 pixels.

-- A communications capability is available.

-- The system has a network capability.

-- A program called Lisa Test can be used to isolate a computer failure to a single board or component.

Disadvantages:

-- Experienced users may get frustrated with system response time when interacting with the system.

-- Since the system is new, it is a relatively unknown quantity.

-- BASIC, Pascal, and COBOL are not currently available.

System Name: Codata 3300

Manufacturer: Codata Systems Corporation
285 N. Wolfe Rd.
Sunnyvale, CA 94086

Telephone: (408)-735-1744

Price: $7,800

Includes: Hardware -- Standalone desktop system, 320KB RAM, 12MB hard disk, 1 floppy disk drive, 2 serial ports; hardware has built-in multiuser capability.

Description:

Beau Vrolyk and Gary Oates left Onyx Corporation and formed Codata. Codata Systems Corporation has been in existence since 1979. The Codata 3300 is a Motorola 68000 based microcomputer system with an

IEEE-796 Multibus chassis. The system comes standard with 320KB RAM and is expandable to 1MB RAM. Originally the system offered XENIX, Microsoft's implementation of UNIX, but this has been replaced wth UNISIS, Codata's own implementation of UNIX. The Merlin operating system is also available.

Languages:

-- FORTRAN
-- Pascal
-- C
-- BASIC
-- APL
-- Assembly
-- COBOL

Advantages:

-- The system contains an IEEE-796 Multibus enclosure.

-- UNISIS, their implementation of UNIX, comes with additional utilities developed by University of California, Berkeley.

-- The system is expandable to 1MB of parity RAM.

-- UCSD Pascal features are implemented in a native code compiler.

-- Up to 4-84MB 8" hard disks may be attached to the system through one SMD/CMD controller board.

-- The system contains forced-air cooling.

-- There is a multiuser capability with a maximum of 18 ports.

-- A 9 track IBM compatible tape drive is available.

-- Unisoft offers a CP/M emulator that runs under UNIX operating systems.

Disadvantages:

-- Compared to Apple or Radio Shack, Codata Systems Coporation has a weak distribution network.

-- The system cannot run CP/M-86 or MS-DOS.

-- UNISIS consumes a large amount of space on the hard disk.

International Marketing:

Codata has authorized dealerships in Belgium, France, Holland, India, Switzerland, and the United Kingdom.

System Name: CORVUS Concept

Manufacturer: Coruvs Systems
2029 O'Toole Avenue
San Jose, CA 95131

Telephone: (408)-946-7700

Price: $4995

Includes: Hardware -- 256KB RAM, processor, keyboard, CRT, network interface, 2 RS-232C.
Software -- Operating system, Pascal.

Description:

The CORVUS Concept is Corvus' entry into office information systems. Based on the Motorola 68000, the Concept comes with a built-in network interface. This makes it easy to connect the Concept into CORVUS' Omninet network. The most impressive characteristic of the Concept is its bi-directional screen. The high-resolution 8-1/2 X 11 inch screen can be rotated 90 degrees to become an 11 by 8-1/2 inch screen. The 8-1/2 X 11 inch screen is ideal for word processing. The 11 x 8-1/2 inch is good for spreadsheet and other applications. The screen also tilts and swivels for the user's comfort.

Languages:

-- Assembler
-- FORTRAN
-- Pascal

Advantages:

-- The system contains an excellent ergonomic design. It is designed for the user's comfort.

-- A high resolution graphics capability is available. The display has 720 X 560 pixels (picture elements).

-- The system can be easily incorporated into a network. The network interface for CORVUS' Omninet is built-in.

-- The RAM is expandable to 512KB.

-- A CP/M emulator is available.

-- An 8" diskette drive with IBM 3740 format compatibility is available.

Disadvantages:

-- There is a limited amount of generalized software available.

-- No BASIC interpreter is available except for a CP/M emulator.

-- There is no sort utility available.

-- Currently there is no communications support other than networking.

-- Only a limited number of hardware peripherals are available.

-- The system utilizes a non-standard bus.

International Marketing:

CORVUS has local representatives in Africa, Asia, Australia, Europe, North America, and South America.

System Name: Sage II

Manufacturer: Sage Computer Technology
195 North Edison Way
Suite 14
Reno, NV 89502

Telephone: (702)-322-6868

Price: $3600

Includes: Hardware -- CPU, 128KB RAM, 1 disk drive, IEEE-488 interface, 2 RS232C serial ports, Centronics printer port.
Software -- UCSD p-System with Pascal, FORTRAN, BASIC, and Assembler.

Description:

Sage Computer Technology was formed in 1981 by three partners interested in developing a high-performance, low-cost microcomputer.(45) They appear to have succeeded. In benchmarks run on both the IBM PC and the Sage II, the Sage II has shown to be faster, and in some cases, several times faster. In one benchmark, the Sage II, executing interpretive Pascal code, executed more than twice as fast as an Intel 8088 based machine executing Pascal converted to native code.(46)

The Sage II System is based on the Motorola 68000 microprocessor. It comes with 128KB RAM, and runs the UCSD p-System as its standard operating system. The UCSD p-System is a highly portable operating system, available on many microcomputers.

Languages:

-- Assembler
-- Pascal
-- FORTRAN
-- BASIC

Advantages:

-- The system including the Pascal, FORTRAN, BASIC, and Assembler languages sells for $3600.

-- The operating system and compilers are highly portable.

-- The system performs very well in benchmarks.

-- Parity RAM is expandable to 512KB.

-- A 15MB hard disk version of the system is available.

-- Memory can be configured to run as "RAM disk" which is a high-speed memory simulation of disk.

-- The system is compact. The terminal is larger than the system.

-- A utility is available to convert CP/M text files into a format that can be used on the Sage in UCSD format.

Disadvantages:

-- The dealership network is weak.

-- The system utilizes a non-standard bus. Some peripheral interfaces are not yet available.

-- The system uses 5-1/4" floppy disk drives instead of the more standard 8" drives.

-- No communications software is available from the vendor.

-- The UCSD p-System does not take full advantage of the potential 512KB RAM.

-- The system manuals are not oriented to the novice microcomputer user.

International Marketing:

Sage has authorized dealerships in England, Germany, Malaysia, Portugal, and South Africa.

System Name: System 150

Manufacturer: Wicat Systems, Inc.
P.O. Box 539
1875 South State Street
Orem, Utah 84057

Telephone: (801)-224-6400

Price: 69500

Includes: Hardware -- 256KB RAM, CPU, Keyboard, CRT, 10MB hard disk, 1 floppy disk drive, 2 RS-232C serial interfaces, 16-bit parallel interface.
Software -- MCS operating system, choice of 1 programming language.

Description:

Wicat is a pioneer in the application of videodiscs for education. It was only natural that they become involved with microcomputers since computer assisted training is a good application for videodiscs. The System 150 is based on the Motorola 68000. It comes with MCS, a real time, multiuser, multitasking operating system, but UNIX is also available. A 10MB hard disk and 1 - 960KB 5-1/4" floppy disk drive are also included as part of the base system.

Languages:

-- COBOL
-- FORTRAN
-- Pascal
-- Assembler
-- C
-- APL

Advantages:

-- The system uses an IEEE-796 standard Multibus.

-- The system has parity RAM.

-- A CP/M emulator and UNIX version 3 are both available.

-- Implementations of the P-STAT, EAL, and BMDP statistical packages are available on the system running under MCS.

-- A very good Microfocus FORTRAN-77 compiler is available under MCS.

-- The system comes bundled and is reasonably priced.

-- The MCS operating system is more user-friendly than UNIX.

-- A 9 track IBM compatible tape drive is available for the System 160, which is a comparable machine to the System 150.

Disadvantages:

-- MCS is not a portable operating system and there is not much generalized software available for it.

-- The system uses a 5-1/4" disk drive instead of the more standard 8" floppy disk drives.

-- The chassis only has space for 6 Multibus slots.

-- Dynamic RAM is used instead of static RAM.

-- The base system must be returned to the factory to be upgraded into a multiuser system.

-- The CP/M emulator runs at one-third the speed of an Intel 8080.

International Marketing:

Wicat has OEM's located in Argentina, Australia, Canada, Colombia, Finland, France, Germany, Guatemala, Haiti, Hong Kong, Iceland, Israel, Italy, Japan, Norway, Philippines, Saudi Arabia, South Africa, Spain, Sweden, United Kingdom, and Venezuela.

International Marketing:

Apple has an excellent dealer/distributor network overseas for its Apple II and Apple III systems (refer to the discussion of the Apple IIe microcomputer for information on their network). However, Apple is placing stringent requirements on dealers for the Lisa. Only a select group of dealers are being authorized to distribute this new system.

11.5.2.6 Zilog Z8000

The Zilog Z8000 was introduced on the market after the Intel 8086. There are two versions of the microprocessor available, the segmented Z8001A, a 48-pin package; and the non-segmented Z8002A, a 40-pin package. The term "segmented" refers to the ability of the microprocessor to access different 64KB sections of memory. The non-segmented Z8002A can only access 1-64KB section of memory. The segmented Z8001A can access up to 128 segments of 64KB for a total of 8,388,608 bytes of memory. The Z8000 offers a powerful instruction set of 32-bit moves and 32-bit arithmetic instructions including multiply and divide.(49)

The Zilog Z8000 is not a popular microprocessor, probably due to its arrival on the marketplace after the Intel 8086, or to Zilog's inability to deliver the processors as originally promised.(50)

System Name: Onyx C8002

Manufacturer: Onyx Systems, Inc.
73 East Trimble Rd.
San Jose, CA 95131

Telephone: (408)-946-6330

Price: $18,500

Includes: Hardware -- CPU, 256KB RAM, 10MB hard disk, 10MB tape backup, 8 RS232C serial ports, 1 serial port and 1 parallel printer port.

Description:

The Onyx C8002 is a UNIX-based multiuser system designed with communications lines for up to 8 terminals. The systems were first shipped in May 1980, making it one of the more proven of the 16-bit systems available today. It is a dual processor system, using a Z8002 as its CPU and a Z80A to control all mass storage functions. Onyx C8002 users often indicate that they are impressed with the response of the system and that it can be used to perform many functions normally done on mainframes.

Languages:

-- BASIC
-- COBOL
-- Assembler
-- C
-- Pascal
-- FORTRAN

Advantages:

-- The system has multiuser capability.

-- It uses the popular UNIX operating system.

-- The system is expandable to 1MB RAM and up to 160MB of hard disk storage.

-- The system supports 4 users well.

-- Good relational data base management systems are available.

-- A UCSD Pascal compiler is available.

Disadvantages:

-- Most of a 10MB hard disk is consumed by the UNIX OS.

-- One cannot have precompiled code (UNITS) in this implementation of Pascal. The user must recompile

everything. Their Pascal compiler was developed in-house and some bugs exist in the code.

-- The system is expensive. It costs $21,995 to get the first user running on the system.

International Marketing:

Onyx has distributors in Asia, Australia, Europe, the Middle East, and in South Africa. They claim to have distributors in "every major city in the world except those in Africa."

11.5.2.7 Dual Processor Units

A number of microcomputers are available that feature two microprocessors working together. In some implementations, one microprocessor serves as a slave to the other performing tasks, typically I/O processing. In other implementations, software can be run on one microprocessor while the other serves as a slave. Some systems offer operating systems that can run software under its appropriate microprocessor. CompuPro's MP/M 8-16, which can run software under either CP/M on an 8085 or CP/M-86 on an 8088, is an example of such an operating system.

The idea behind most dual processor microcomputer implementations available today is to ease the transition from the 8-bit to the 16-bit processing world. Although many of the 16-bit microprocessors have designs based on their 8-bit predecessors and have some similar or identical instructions, none offers complete upward compatibility. By using a dual processor system, the user can run software already available for the 8-bit microprocessor and gradually phase in the use of the 16-bit microprocessor as software becomes available.

System Name: CompuPro System 816/A

Manufacturer: CompuPro Division
CompuPro Electronics
Oakland Airport, CA 94614-0355

Telephone: (415)-562-0636

Price: $5495

Includes: Hardware -- Desktop enclosure, 128KB RAM, 2 disk drives with controller, dual processor board, 4 RS232C serial, 1 parallel, and 1 Centronics port.
Software -- CP/M, CP/M-86, M-Drive, SuperCalc-86, and dBASE II.

Description:

In 1974, CompuPro Electronics offered its first memory board kit for microcomputer enthusiasts. The response was so positive that it encouraged the company to place more emphasis on its computer

products such as memory and CPU boards, motherboards, and interfaces. CompuPro Electronics has an excellent reputation for distribution of rugged, durable, and reliable computer equipment. It also has a reputation for being one of the first, if not the first, to implement new technologies on IEEE-696/S-100 boards.

The System 816/A is CompuPro's entry level single-user system. It is based on a dual processor board containing both the Intel 8085 and 8088 microprocessors. The system is contained in a 20 slot IEEE-696/S-100 enclosure and includes 128KB RAM. The 2-8" floppy disk drives provide an online storage capacity of 2.4MB. Both CP/M and CP/M-86 can run on the system with their accompanying software and compilers.

Languages:

-- BASIC
-- COBOL
-- FORTRAN
-- Pascal
-- C
-- Assembly
-- Any compilers or interpreters that run under CP/M or CP/M-86

Advantages:

-- The system has a good price for an S-100 based system.

-- It runs the popular CP/M and CP/M-86 operating systems.

-- The system uses an IEEE-696/S-100 bus implemented in a 20-slot chassis.

-- The vendor has a good reputation for building durable and reliable computer components.

-- The system is expandable and upgradeable. The vendor has a reputation for being quick to implement new technologies.

-- Many peripherals can be added since many vendors offer S-100 controller boards.

-- The system uses static RAM instead of less reliable dynamic RAM.

-- Standard 8" floppy disk drives are used, each with 1.2MB capacity.

-- The vendor offers a 2 year warranty on boards with direct replacement.

-- The system can be upgraded into a multiuser system.

-- The system is expandable to 1MB RAM.

-- M-Drive software treats high-speed memory as disk. This can greatly increase the speed of program execution.

-- The 8MHz 8088 CPU runs 60% faster than the IBM PC's 4.77 MHz CPU.

-- The MBP COBOL compiler, which generates native machine code instead interpretive code, is available.

Disadvantages:

-- The systems's RAM does not have parity.

-- The technical documentation is weak.

-- The user support at vendor's headquarters is lacking.

-- The technology is new and the user community is relatively small.

-- There are very few CompuPro systems centers.

-- No communications software is available for the Interfacer 4 board.

-- The system does not have a graphics capability as a standard feature.

International Marketing:

System centers are located in the U.S., Canada, and Wales. Only system centers are authorized to repair CompuPro boards under warranty. Dealerships for equipment are located in the U.S., Australia, England, and New Zealand.

<u>System Name</u>: DEC Rainbow 100

Manufacturer: Digital Equipment Corporation
146 Main St.
Maynard, MA 01754

Telephone: (617)-897-5111
(800)-344-4825

Price: $3495

Includes: Hardware -- 64KB RAM, CRT, keyboard, 2 floppy disk drives.
Software -- CP/M 86/80.

Description:

The Rainbow 100 is a dual processor system that incorporates both the Z80 and 8088 microprocessors. Each processor acts as a controller when the other is operating as the CPU. The video

display features a 132 column format and a graphics option is available. The keyboard has, in addition to the usual QWERTY keyboard, a numeric keypad, and function keys. Either CP/M or CP/M-86 software can be run under the CP/M 86/80 operating system.

Languages:

-- At this time, DEC does not market CP/M or CP/M-86 software. Users must go to a software house to obtain software.

Advantages:

-- The system has a good implementation of CP/M which provides a menu driven interface.

-- The system has a good ergonomic design. It contains a detachable, low profile keyboard and a CRT that tilts and swivels.

-- There is a good distribution network for hardware.

-- The display can present 132 characters of text on a line.

-- Color graphics capability is available.

-- The MS-DOS operating system is available.

Disadvantages:

-- DEC does not market any software for the system. Users must buy from software houses.

-- The memory is only expandable to 256KB.

-- A hard disk is not currently available for the system.

-- The system uses 5-1/4" disk drives instead of more standard 8" drives.

-- The system is relatively new.

International Marketing:

Digital Equipment Corporation has field managers in Austria, Belgium, Denmark, England, Finland, France, Holland, Ireland, Israel, Italy, Norway, Spain, Sweden, Switzerland, West Germany, and Zurich.

<u>System Name</u>: Radio Shack TRS-80 Model 16

Manufacturer: Radio Shack
1800 One Tandy Center
Fort Worth, TX 76102

Telephone: (817)-390-3272

Price: $4,999

Includes: Hardware -- CPU's, 128KB RAM, 1 disk drive, keyboard, CRT.
Software -- operating system.

Description:

This system incorporates the Zilog Z80A and the Motorola 68000 as its co-processors. The Z80A can run software compatible with the TRS-80 Model II. The 68000 uses XENIX as its operating system, which is Microsoft's implementation of UNIX, a popular Motorola 68000 operating system. When software is running under the 68000 microprocessor, the Z80A serves as a slave, performing I/O functions for the 68000. The system includes a 1.25MB 8" floppy disk drive and an option is available for high resolution graphics.

Languages:

- -- BASIC
- -- Assembler
- -- COBOL

Advantages:

- -- The distribution network is good. Radio Shack has a strong network of outlets overseas.
- -- The system can run software running on the TRS-80 Model II and can also run UNIX software.
- -- It uses a standard 8" floppy disk drive.
- -- With the graphics option, high resolution graphics (640 by 240 pixels) can be generated.
- -- The system has multiuser capability.

Disadvantages:

- -- XENIX has just been released for the system. Little is known about its performance in this implementation.
- -- The 512KB RAM maximum does not seem adequate for a system that is multiuser and offers the Motorola 68000 microprocessor which can directly access 16MB RAM.

International Marketing:

Radio Shack has company owned operations in Australia, Belgium, Canada, France, Germany, Holland, Japan, and the United Kingdom.

# FOOTNOTES

1 Greggory S. Blundell, "Personal Computers in the Eighties," BYTE Magazine, Vol. 8, No. 1 (January 1983), p. 172.

2 Cary Lu, "Microcomputers: The Second Wave," High Technology (September/October 1982), p. 40.

3 David Bunnell, "A PC Exclusive Interview with Software Guru Bill Gates," PC, Vol. 1, No. 1, p. 19.

4 Ibid.

5 Ibid., p. 18.

6 "8-bit vs. 16-bit: A Decision for Business," Business Computer Systems (September 1982), p. 104.

7 Lu, Second Wave, p. 41.

8 Elizabeth Horwitt, "When More May Not Be Better," Business Computer Systems, Vol. 2, No. 2 (February 1983), p. 72.

9 Ibid.

10 George Kotelly, "Personal Computer Networks," EDN, Vol. 28, No. 5 (March 3, 1983), p. 83.

11 Ibid.

12 Ibid., p. 85.

13 David Kline, "The Micro Comes to Pakistan," Datamonitor, Vol. 28, No. 9 (August 1982), p. 90.

14 Rodnay Zaks, From Chips to Systems (Berkeley: Sybex, 1981), p. 256.

15 Allan Flippin, "The 16-bit Time Trials," Microcomputing, (October 1980), p. 182.

16 Ibid., p. 342.

17 Ibid., p. 126.

18 Winn L. Rosch, "Hard Disks Made Easy," PC, Vol. 1, No. 10 (February 1983), p. 272.

19 Lu, Second Wave, p. 45.

20 Bob Metcalfe, "Controller Transceiver Board Drives Ethernet into PC Domain," Mini-Micro Systems, Vol. 16, No. 1 (January 1983), p. 183.

21 Zaks, Chips to Systems, p. 226.

22 "Atari 400 and Atari 800 Home Computers," *Datapro Directory of Small Computers*, Datapro Research Corporation (October 1982), p. SC30-80-101.

23 Robin Moore, "Apple's Enhanced Computer, the Apple IIe," Vol. 8, No. 1 (February 1983), p. 80.

24 Zaks, *Chips to Systems*, p. 227.

25 "Osborne I," *Datapro Directory of Small Computers*, Datapro Research Corporation (July 1981), p. SC30-710-101.

26 John Markoff and John C. Dvorak, "Osborne Unveils its Second Generation," *Infoworld*, Vol. 5, No. 18 (May 2, 1983), p. 1.

27 "Kaypro II and Kaypro 5," *Datapro Directory of Small Computers*, Datapro Research Corporation (December 1982), p. SC30-580-101.

28 Hillel Segal, "Altos Sows Performance Gap Between Disks," *Computerworld* (January 11, 1983), p. 30.

29 Gregory Marks, "Microcomputers: Basic Choice Factors," (The University of Michigan, June 1982), p. 15.

30 Ronald Steele, "Utilization of Microcomputers to Process Agricultural and Economic Survey Data in Developing Countries: A Survey of Activities of the Statistical Reporting Service," (U.S. Department of Agriculture, May 1982), p. 7.

31 Hillel Segal, "Chieftain 9822 Gives High Performance Rates," *Computerworld*, Vol. 16, No. 10 (March 8, 1982), p. 42.

32 *Ibid*.

33 *Ibid*.

34 Zaks, *Chips to Systems*, p. 245.

35 Jim Edlin and David Bunnell, "Taking the Measure," *PC*, Vol. 1, No. 1 (February 1982), p. 42.

36 "PC Product Guide," *PC*, Vol. 1, No. 5 (September 1982), p. 115.

37 Marks, *Choice Factors*, p. 12.

38 *Ibid*.

39 David Wedemeyer, "Letters to PC," *PC*, Vol. 1, No. 4 (August 1982), p. 12.

40 Phil Lemmons, "Victor Victorious: The Victor 9000 Computer," *BYTE Magazine*, Vol. 7, No. 11 (November 1982), p. 216.

41 Johanna Ambrosio, "Ford Selects Victor 9000 for Execs," Information Systems News (December 27, 1982), p. 5.

42 Lammons, The Victor 9000 Computer, p. 246.

43 "Wang Professional Computer," Datapro Directory of Small Computers, Datapro Research Corporation (February 1983), p. SC30-908-101.

44 Ibid.

45 "Sage II," Datapro Directory of Small Computers, Datapro Research Corporation (November 1982), p. SC30-769-101.

46 Jerry Pournelle, "User's Column: Sage in Bloom, Zeke II, CBIOS Traps, Language Debate Continues," BYTE Magazine, Vol. 8, No. 3, (March 1983), p. 220.

47 Gregg Williams, "The Lisa Computer System," BYTE Magazine, Vol. 8, No. 2 (February 1983), p. 50.

48 "Apple Takes on its Biggest Test Yet," Business Week, (January 31, 1983), p. 74.

49 Zaks, Chips to Systems, p. 256.

50 Ibid., p. 255.

# CHAPTER 12: METHODOLOGY FOR INTRODUCTION OF MICROCOMPUTERS

Introduction of microcomputers into an office often has far greater ramifications than changing from an existing mainframe computer to a larger or different mainframe computer. By offering the potential to computerize activities formerly done by hand or to radically change other processing approaches, microcomputers have complicated decisionmaking and added a whole new realm of issues to be addressed. Seymour Papert in his book Mindstorms comments that computation is in its infancy; that it is hard to think about computers of the future without projecting onto them the properties and the limitations of present-day computers.(1) In this same vein, it is difficult but necessary to think of microcomputers as a new technology that demands not a scaled-down mainframe approach, but rather a rethinking of many important issues.

The intent of this chapter is to examine some of the institutionalization issues involved in introducing microcomputers. These issues extend beyond how to go about obtaining microcomputers to embrace organizational, managerial, sociological, and procedural implications.

It is worthwhile to formulate a systematic plan for incorporating microcomputers as new tools to do the work of an office. This plan will examine existing and potential applications for one or more microcomputers, procurement of hardware and software, and organizational and procedural changes.

## 12.1 Developing Microcomputer Literacy

The first undertaking should be development of microcomputer literacy among a group of people who are a mix of technicians and persons with managerial authority in the office. Their goal would be to obtain a realistic understanding of the technology, to appreciate its strengths and weaknesses, and to look at examples of microcomputer application.

## 12.2 Looking at Positive and Negative Effects

An important issue for this group will be that of cost. Microcomputers are often thought of as an inexpensive solution of problems when, in fact, only the hardware cost is a bargain. The "hidden costs" which must be examined include the following:

- -- The cost of developing customized software when no packaged software exists.
- -- The cost of giving those involved minimal skill levels to enable them to use the equipment effectively.
- -- Recurrent costs associated with maintenance and repair.(2)

The incorporation of microcomputers into an office is clearly a form of distributed decentralized processing, as opposed to centralized processing. (This is true unless a single

microcomputer is acquired and it is the only computing tool for the office.) It is highly likely that decentralization will result in greater cost primarily due to expansion of computing once the user has control of the resource. This is not necessarily a feature of decentralization, but a result of delight with new technology. People tend to want increasingly sophisticated, high-quality technology.(3)

Despite the fact that microcomputers may not save money, the group will want to examine the benefits of the technology. They are primarily concentrated in those applications that assist in conducting routine, well understood tasks. Computing does improve the speed and accuracy with which some jobs can be carried out and, as a result, produces the opportunity for staff hiring avoidance and cost avoidance, and it can bring important qualitative improvements in operations.

Benefits from applications which address more complex and uncertain tasks such as management decisionmaking are much more difficult to ascertain, however; unfortunately, many of these, such as "improved information," are intangible.(4)

The group must look beyond a few highly successful applications to what has happened in many organizations to have a realistic idea of what to expect. They will see many cases of incompatible equipment and microcomputers idle because of inadequate training or maintenance problems.

As they review the technology they should systematically list positive and negative points, much as done in the following example:

| Opportunity | Danger |
|---|---|
| A computer may be used by anyone having an application that can be put on a computer. | The small computer may not be the best solution. Complexity, need for secure permanent files, and processing requirements may dictate a bette approach. |
| Each user will be able to control his/her own data. | Data security will be a problem. Redundant and incorrect data could spread. |
| Systems can be developed and made operational very quickly by using "off the shelf" software and hardware. | Ineffcient and poorly designed systems could proliferate. Duplication of effort could occur. |

| | |
|---|---|
| Software packages can be used instead of writing programs. | The package purchased may not be the best solution available, or may not even do all it is advertised to do. |
| Computing power is not concentrated in a single machine, and subject to its failings and limitations. | An array of different machines may develop, which may not be compatible in all desired areas. |

The opportunities and dangers of this technology exist equally. Care must be taken to avoid the dangers, while still making the most of the opportunities.(5) Observations such as these contribute to the ultimate set of guidelines for the office's use of small computers.

## 12.3 Developing a Policy

Armed with a knowledge of microcomputers and their strengths and weaknesses, the group should then focus on whether or not the technology is appropriate for their office and how microcomputers could best be incorporated into the existing computing environment.

This involves doing an organizational diagnosis which examines authority relationships, modes of formal and informal communication, use of existing computing facilities, and deficiencies in the current mode of operation.(6) It is likely that they will decide that the strengths of microcomputers could complement existing mainframe capabilities or provide capability where none currently exists. For this reason, they will pursue the introduction of microcomputers. In the course of reaching this decision, they will have formulated some definite ideas about goals and guidelines for microcomputers within their office. These ideas constitute the beginning of a microcomputer "policy" for the office.

Such a microcomputer policy might address a number of issues, among them being standardization, software, environment, communication, maintenance, training, support, and control. The following is an example of the policy the group might set down:

-- A microcomputer may be considered as a possible tool for any new or ongoing application. A "Summary of Benefits" form must be filled out and submitted to the Microcomputer Committee for approval to use a microcomputer for a particular application.

-- Hardware need not be limited to one vendor. However, the hardware solution must be appropriate to the application. Any machine chosen must have the capability to communicate with the mainframe either via telecommunications and

communications software or via floppy disk. The latter implies the ability to produce an 8" floppy disk in IBM format.

-- The degree of system customization will be up to the user. However, the vendor must be obligated to integrate and install the system; this responsibility will not be assumed by the office.

-- Each microcomputer which is not already represented in the office must be purchased with a complete set of spare boards and chips. Maintenance will be the responsibility of the central staff which now maintains the mainframe computer. If a problem cannot be corrected by this staff, the faulty component will be sent to the closest source of maintenance for repair. The budget submitted for each microcomputer application must include 5% of the purchase price per year for maintenance.

-- Training in the fundamentals of microcomputer usage, including courses in the BASIC and Pascal languages, and packaged software yet to be identified, will be provided by the office training staff. Additional training for a specific microcomputer will have to be acquired by self-study or from the vendor who supplies the system. It is recommended that at least 10% of the purchase price be budgeted for training.

-- The Microcomputer Committee will offer hardware and software support to users and potential users in the procurement and use of microcomputer systems. This will include evaluating new hardware and software and making recommendations. If the committee members are unable to respond to an inquiry, they will attempt to put the user in communication with the appropriate person.

-- A clean, dust-free environment must be provided for any new microcomputer. A UPS must be procured to provide adequate power conditioning and backup since the local power supply is not dependable.

-- Each microcomputer application should take advantage of packaged software, where it exists and is appropriate. Purchased software will not be copied in violation of any copyright laws.

-- Users will be responsible for the safety and integrity of their own data. The Microcomputer Committee will be available to make suggestions and recommendations.

This policy gives individual users a great deal of freedom. Clearly, one way to minimize the cost of the overall investment of the office is to centralize procurements among a small set of products which effectively become organization standards. The benefits of this type of standardization include:

-- Improved vendor relationship, brought about by familiarity and greater sales potential.

-- Better understanding of the selected products, their capabilities, and their limitations.

-- Less time spent on in-house support: installation, hardware and/or software upgrade, problem diagnosis, and repair.

Limiting acquisitions to a small set of products greatly improves the cost effectiveness of microcomputers for larger organizations.(7) On the other hand, this restriction has the disadvantage of locking the organization into a set of products that may quickly become obsolete or pose identical problems. An office may wish to compromise by offering central support, maintenance, and training for certain products, but not restricting procurement to those products if users have a demonstrated need for other products and have the resources to support them.

Once a policy is formulated, the group now known as the Microcomputer Committee must determine a plan for implementing it. This plan should draw heavily on the input of potential microcomputer users.

## 12.4 Introducing Microcomputers

The "mode of transfer" or the way microcomputer technology is introduced into an office is critical to its initial adoption and continued use. The first step might be a short seminar to make potential users aware of microcomputer technology and to solicit from them ideas for potential microcomputer applications. These should not be limited to new applications, but could possibly include conversion of existing mainframe systems that are problematic or inefficient. Information collected for each application should include: system description (if already written), quantity of data, frequency, output requirements, need for particular software packages, number and organizational relationship of persons involved in processing, timing requirements, and budget.

The Microcomputer Committee would evaluate all the potential applications. Evaluation would include storage requirements, conversion potential (if system already exists), need for mainframe communication, budget, staffing needs, and benefit to the office. Applications would be ranked in priority order according to a combination of these factors, which would balance the chance for success and benefit to the office.

The introduction of microcomputers in the office should be approached incrementally. A rapid pace involving a large number of applications over a broad range of users may cause failures, widespread disillusionment, and implementation of incompatible systems.(8) The establishment of the proper internal infrastructure is a gradual building process.

The Microcomputer Committee should work with the potential users slated to receive the first microcomputers. If this is a small office, these users may be committee members! They should follow the ideas suggested in the chapter dealing with criteria for selection in determining appropriate hardware and software. They should also plan for procurement of hardware, software, and supplies (including customs problems); maintenance; training; and support. This initial experience may show the need to modify the office policy as described above. It will be important to maintain open communication between the Microcomputer Committee and the users.

## 12.5 Organizational Implications

It is obvious that the introduction of microcomputers will cause at least some organizational changes, or at least the need for a certain level of training. The formation of a Microcomputer Committee to oversee the administration of a policy and to offer central support implies at least one fulltime position. These persons will require self-study or formal training in order to assume this position of expertise. The central training staff may possibly need to be expanded to support a person to offer training in the use of microcomputer hardware and software. If a knowledgeable person is not hired, then one or more existing staff members must be fully trained. The staff in charge of maintaining the mainframe computer will need to be augmented to include a person who knows how to do rudimentary microcomputer maintenance, such as board- and chip-swapping. Once again, an existing staff member could receive training in these skills.

The greatest impact may be felt by the users themselves. Because of the utility of microcomputers to persons outside the computing field, there will be a need for an extensive "learning from scratch" of already well known computing principles by young technologists in other disciplines. There will be an increasing demand for staff with experience both in hardware and software to analyze new developments and design new total systems to a professional standard.(9)

The Microcomputer Committee should organize periodic user group meetings to offer a forum for exchange of experiences, software recommendations, and technology updates. The individual users should be well aware of the work of other users in the office.

The introduction of microcomputers in no way lessens the need for a strong data processing staff. These persons should, instead, be the leaders in using the new systems and in assisting other users who lack data processing experience. Although microcomputers make it possible for this latter group of people to do productive work quickly, the need for qualified data processors to do custom programming, trouble-shooting, and training will only increase.

The above discussion supposes the ultimate purchase of multiple microcomputers by an office. If the size, budget, or level of activity of the office indicates the purchase of a single

microcomputer, then many of these comments can be scaled down. However, successful integration of even a single microcomputer carries with it the requirement for proper organizational backing, training, maintenance, and support.

If in-house capability is not adequate to meet these needs, the office may wish to hire a consultant or solicit technical assistance at least in the initial phases of microcomputer introduction. It may even be more cost effective to rely on the expertise of a person or group of people who have had experience and can offer beneficial advice and training.

### 12.6 Procedural Implications

The introduction of microcomputers will undoubtedly result in procedural changes. Applications which are selected for microcomputers will probably become much more interactive in nature. At least a degree of editing may be done at data entry time. Systems will be designed to avoid numerous passes of the data because of the slow speed of microcomputers. Analysts may substitute certain statistical routines or graphics programs for a portion of processing previously supported only by crosstabulation.

Additional responsibility to safeguard the data and to care for the equipment will be placed on the users. They will be responsible for maintaining the integrity of files and programs and backing them up. They will need to keep the microcomputer room clean and enforce rules such as prohibiting eating and drinking while working at the machine.

Usage of the mainframe computer will probably not diminish, but may change in nature. More "number-crunching" and I/O bound jobs may take the place of program development and small processing jobs. The supposedly more powerful machine will be used for what it does best.

Microcomputer introduction has the potential to impact on management approach. By being offered more timely information, managers can theoretically gain more control of the actual work situation by being able to analyze alternatives and better understand the implications of particular decisions. Unfortunately, the whole process of using microcomputers to improve institutional management is new, dynamic, frustrating, and chaotic; it has the potential for changing one's views of management in much the same way the telephone changed one's manner of communication.(10)

Even with a microcomputer in an office, there is no substitute for good, solid internal management procedures and policies. Furthermore, managers should beware of the tendency to equate information processing with management improvement. Just having a microcomputer does not imply getting more or better work done!(11)

## 12.7 Sociological Impact

The potential sociological impact of microcomputers on an organization needs to be addressed. Any new technology immdiately indicates possible loss of jobs to a certain segment of personnel. Staff who have done data entry, program entry, or even program development, may feel threatened by the advent of interactive systems which make heavy use of packaged software. Craig J. Calhoun appropriately comments that we have utterly failed in modern societies to find a way of humanely and productively dealing with technological obsolescence. He suggests that there is no reason why, given appropriate planning, microcomputers cannot improve and rehumanize work.(12) The same people who fear unemployment can be incorporated into the microcomputer applications in new and productive capacities.

## 12.8 Epilogue

As an epilogue to this chapter on the introduction of microcomputers, it is fitting to point out that if a mistake is made in attempting a microcomputer application, it may be far less disastrous than if a mainframe computer were involved. Bill Morris of Purdue Univeristy refers to microcomputers as "consumable items" which do not have to do much to "earn their keep."(13) This is not to say that a realistic approach should not be followed in considering hardware and software to meet user needs. However, if problems arise and are identified before too much is invested in human resources, the loss is most likely not significant.

## FOOTNOTES

1 Seymour Papert, Mindstorms (New York: Basic Books, Inc.), p. 5.

2 "Microcomputers and Agriculture Management in Developing Countries: Workshop Proceedings" (USDA, June 1982), p. 14.

3 Robert Goldberg and Harold Lorin, The Economics of Information Processing (New York: John Wiley and Sons, 1982), p. 76.

4 Ibid., p. 77.

5 Robert St. John, "Proposed Policy Memo Is First Step to Control," Small Systems World (September 1982), p. 26.

6 USDA Workshop Proceedings, p. 12.

7 Jeffrey Stone, "Microcomputer Selection Study," (World Bank: July 16, 1981), p. 12.

8 Arthur Young, "The Impacts of Low Cost Computing Technologies on the Department of Defense" (1982), p. 8.

9 E.B. James, Microelectronics: The Impact on Computer Centres," Computer Journal, Vol 24 (February 1981), p. 12-13.

10 USDA Workshop Proceedings, p. 3-4.

11 Ibid., p. 14-15.

12 Craig J. Calhoun, "The Microcomputer Revolution," Sociological Methods and Research, Vol. 9, No. 4 (May 1981), p. 442, 431.

13 W.H.M. Morris, "Case: West Africa/Purdue" (MSU Conference, May 1982), p. 4.

# CHAPTER 13: GUIDELINES FOR USING MICROCOMPUTERS IN NSO'S

## 13.1 Mainframes, Minicomputers, and Microcomputers: Distinction of Function and Capability

In 1983, it is difficult to draw clear lines of delineation between mainframe computers and minicomputers or between minicomputers and microcomputers. Further, the predictions of industry analysts suggest that the distinction will become even cloudier in the future as the power of small systems increases. Already, the so-called supermicros provide strong competition for mid-range minicomputers, and any attempt to distinguish systems by performance will be frustrated by the enormous gains in power predicted for microcomputer systems. Nevertheless, the categories of mainframe and microcomputer continue to be used because they provide a useful and meaningful distinction between broad types of systems available today.

Setting aside the consideration of cost, there are a number of ways that mainframes and microcomputers differ. One important distinction is that of vendor support. Mainframes (and minicomputers) typically are better supported by the firms that sell them. This support is also more comprehensive, in the sense that it extends from installation and maintenance to the development of technological improvements of both hardware and software and provision for the training of staff in the computer's operation.

A second major distinction is in the number, the capacity, and the types of peripheral storage devices that may be attached to the system. Mainframes may have banks of tape and disk drives that allow billions of bytes of data to be on-line; the software provided for these systems is designed to support this scale of operation. Although the limits of on-line storage are rapidly being pushed upward, microcomputers capable of supporting more than 100 million bytes of on-line storage or a 9-track tape drive are the exception rather than the rule.

The sophistication and power of operating systems and the overall integration of system software is another area where a distinction can be discerned, although it fades dramatically at the upper end of microcomputer technology. Most microcomputer operating systems are basic systems that must be augmented by packaged software from a variety of sources to reach full functionality. Management of memory, even when large amounts of RAM are available, is much more rudimentary on microcomputers.

A fourth distinction is the de-emphasis of printed output with the microcomputer. Printed copy is a primary means of communication between the user and the computer on mainframe systems. Mainframes, consequently, provide support for fast line printers that make large printing jobs feasible. Microcomputers, on the other hand, rely on interactive CRT terminals and are most often limited to slow character printers unsuited to such tasks.

A fifth distinction, and perhaps the cloudiest one of all, is that of speed of operations. Although microcomputer speed is inc easing steadily, mainframes still process data at much faster rates. Microcomputer speeds that may seem entirely satisfactory when working with small data files or in the development of software may be a limiting factor when larger jobs are involved.

All of the distinctions listed to this point have implicitly taken mainframe performance as a standard and noted what might be termed deficiencies of the microcomputer in each of these areas. At least two distinctions must be made in the opposite manner. First, less support is required to make the computer operate, and the degree of intervention that is required when things go wrong is much more limited. This is so because the scale of operations performed on a microcomputer is typically smaller and less complex than that on a mainframe. On a single-user system, if a user's error brings operations to a halt, it is a simple matter to restart the computer and begin again. Operating systems do not need to be overly complex because operations are small-scale. Similarly, if only one user has access to a collection of data files, there is not much need for record and file locking software, and the user can assume responsiblity for documenting the various stages of a data file's development.

Secondly, much microcomputer software has been designed to capitalize on the microcomputer's suitability for single-user operation by emphasizing interactive processing, i.e., data processing in which the computer user is able to repeatedly monitor and specify the direction that processing is to take while it is in progress. Although mainframes may be equally capable of providing an interactive interface for users, batch processing is more common on mainframes than it is on microcomputers because it is an easy and efficient way to service the needs of many users without the added software support required for interactive processing for multiple users.

Each of these distinctions between mainframes and microcomputers has implications for the types of work for which microcomputers will be used in NSO's and for the way in which statistical processing will procede when microcomputers are employed. Plans for using microcomputers must take into account the limitations and the advantages of these smaller computer systems. The fact that the speed and memory size of some microcomputers today exceed that of many mainframe computers used effectively fifteen years ago suggests that microcomputers should find numerous useful applications in an NSO.

Choosing an appropriate computer environment for computer processing jobs must begin with a careful and detailed examination of processing requirements. Special attention should be given to the following:

-- The quantity of data to be processed and the size of files that will be required,

-- The frequency with which routines tasks must be carried out,
-- The software requirements of the job,
-- The desirability or need for interactive processing,
-- The quantity of printed output required,
-- The time available for completing the job.

It is often difficult to specify the best computer environment, even when there is a real choice. When mainframe computing capability is available it is important to be able to identify tasks that could be done better on a microcomputer. If the processing job that has been described

-- can be accomplished best by a single-user,
-- involves relatively small amounts of data that can be logically and conveniently kept in small files,
-- requires or would benefit from interactive processing and the ability to access and modify screen-sized parcels of data quickly and easily,
-- does not require frequent time-consuming batch processing of files,
-- can rely entirely on available software packages for processing, and
-- does not require large amounts of printed output,

then the job is ideally suited for a stand-alone, single-user microcomputer. A qualification of any one of these factors could suggest the need for a more complex arrangement of microcomputers, use of a mix of microcomputer and mainframe processing, or a need to move entirely to a mainframe environment.

If, as in a data entry operation, for example, it is important to maintain a single file that can be accessed by many users, a multiuser or networked microcomputer system might be feasible. If data files are large or time-consuming batch processing is necessary, it may be possible to separate the processing job into functional tasks, some to be accomplished on a small microcomputer, others on a larger computer system more suited to handling large files and batch processing. Further, if voluminous camera-ready table production is required, the mainframe computer may be the best choice because of the availability of packaged tabulation software and a high-speed printer.

When mainframe computing is an alternative, the microcomputer may still be an appropriate choice even though the computing application appears less than ideally suited to the microcomputer. Consideration should be given to the following:

-- The accessibility of the mainframe computer,
-- The reliability of the mainframe and the consequence of a long period of system failure for the work being planned,
-- The abilities of the computer support staff,
-- The availability of outside support for use of the microcomputer,
-- The possible need to transfer processing to a different system or environment at another time,
-- The cost of the two alternative approaches.

If mainframe computer time is already scarce, or if users must wait long periods of time for access to the mainframe, the microcomputer may offer a solution. Not only would the microcomputer be more accessible, but the chances for successful completion of the project might be significantly improved. If the mainframe is unreliable and does not operate at all a significant portion of the time, this alone may be sufficient reason to opt for the development of a microcomputer-based system, even if it were to mean accepting a less straightforward processing design. On the other hand, if existing computer staff are not trained in the operation of microcomputers and microcomputer software, training will have to be provided if the microcomputer is to be used successfully. The need for training, equipment maintenance, and support in dealing with problems as they arise must be addressed if a microcomputer is chosen.

General guidelines:

Microcomputer characteristics make it especially well-suited for certain types of activities, especially those applications involving small quantities of data and printed output that benefit from interactive processing and that can capitalize on available packaged software. Compare computer processing requirements with microcomputer and mainframe capabilities.

If a mainframe computer exists, but is difficult to use or is largely unavailable due to overuse or maintenance problems, the microcomputer may be an attractive alternative source of computing power. It is important, however, to consider the need for staff training and support for both maintenance and use of the microcomputer.

If a stand-alone microcomputer system cannot be relied upon to meet all processing requirements, evaluate the feasibility of using a multiuser or networked microcomputer system. If mainframe capability is available, it may be possible to identify functional tasks that are best suited to the microcomputer and others that are best suited to the mainframe. With careful planning, the microcomputer and the mainframe can be used as complementary systems, sharing the processing load.

## 13.2 Batch and Interactive Processing

Batch processing involves the submission of a series of commands sufficiently complete to enable the computer to complete a useful task before it returns to an inactive state. This approach to processing has been used in traditional mainframe computing in order to make efficient use of a costly central processing unit. It requires that computer users think out and then describe the full requirements of a job before the computer is asked to perform it. Once the computer receives a batch job, there are only two paths the batch request can follow; it can be successfully completed, or it can fail. If the job succeeds, the user is presented with a report of its success; if it fails, a report of

the failure, and possibly some information on why the job failed, is returned. The user can modify the set of commands and resubmit the request, but he must return to the start of the task that failed.

The microcomputer, with its low-cost microprocessor, makes it reasonable to dedicate an entire computer to a single-user and a single task. With only one task being performed by the system at any time and with processing time now inexpensive, there is no longer reason for concern about the efficient use of the central processing unit and it is feasible to allow the computer to sit idle while a user considers alternative processing paths or the way to handle an unexpected error. This approach to computer use, in which the user is able to carry on what appears to be a conversation with the computer, selecting one from among several options as processing proceeds or responding to a question asked by the computer, is termed interactive processing. It has been one of the distinctive characteristics of the microcomputer from its introduction as a general purpose system, and one which most strongly recommends the microcomputer in the performance of many non-routine processing tasks. The advantage of this approach is that the user may be lead through a processing task and allowed to make decisions at times when the information necessary for making the decision is available rather than at the start of processing when less may be known. The major disadvantage to this approach is that the user may be forced to be present for the duration of what may perhaps be a lengthy processing task.

One area in which the interactive approach to processing is an unqualified advantage is text or word processing and custom program development and testing. The use of full-screen editing capabilities in entering and correcting documents, data, and computer programs is enormously advantageous, saving great quantities of both time and paper. NSO's will want to capitalize on these microcomputer capabilities by using microcomputers for the preparation of manually typed tables, training manuals and other word processing tasks. The microcomputer promises to offer an inexpensive means of supporting the work of computer programmers, as well. Program development and testing can procede more quickly using the text editors and programming aids offered on microcomputers, without requiring mainframe support in these time-consuming activities.

A second area in which interactive processing promises to be the more desirable alternative is that of editing at the time of data entry. The advantage of an interactive approach to data entry is that the computer may quickly check for type, range, or consistency errors and report on, or require a response to, errors when found. This advantage may be partially offset by other factors. When large quantities of data are being keyed, or perhaps read by OMR or OCR equipment, it is not always best to allow or require an interruption of the data entry process that may slow the process. Further, the keyer or the person operating the data entry equipment may not have the necessary information or knowledge to correct the errors uncovered by the computer. Some compromise approach,

allowing data entry to proceed unhindered to a convenient point at which errors can be identified and dealt with, could address this problem but retain the advantage of the interactive approach. Allowing records with errors to be flagged for later editing by a supervisor can place responsibility for corrections in the hands of a person qualified to make a decision on the correction.

Microcomputers may serve well as an inexpensive and flexible alternative to traditional key-to-disk devices. Microcomputer software is available to support the development of custom routines for data entry, editing, and verification, and, with careful planning, even large data entry projects will be effectively and efficiently implemented on small systems.

Interactive processing would appear to be preferable to batch processing in data editing, and it may be so when small data files or small numbers of errors are involved. When large data files are being managed or the number of errors is large, a plan for handling errors, consistently followed, becomes important, and batch processing is more suited to carrying it out. One of the most serious disadvantages of interactive processing in data editing is that it normally fails to leave a documented trail of the editing that has been done. When packaged microcomputer software is used for data editing, the user will have to provide the trail manually, if it is to exist at all. Control of the quality and accuracy of data is difficult in any circumstance, but, when interactive editing is used, the problems of control are considerably increased.

One of the more impressive capabilities of the microcomputer is its ability to support the maintainance and use of small data bases. This capability is built upon the ease with which the microcomputer can access, display, and modify single data records in an interactive environment. Disaggregate national statistical data, for all but the smallest countries, will exceed the normal capacity of microcomputer systems. Data bases containing aggregate or summary statistics from tables, however, may be well within the limits of microcomputer capacity, and the microcomputer may serve as an effective way for NSO's to put data into the hands of analysts and policymakers. In addition, the microcomputer offers simple graphics capability at low cost. The effective use of graphics is, however, dependent upon the availability of skills in graphics design among statisticians and analysts.

In production work, batch processing becomes the desirable alternative. The ability to submit a request for many frequency distributions or crosstabulations that can be completed in a single pass through a large data set, leaving the computer unattended until the job is completed, is not an insignificant advantage, as the frequent user of an interactive microcomputer statistical packages will soon learn. One of the features of the microcomputer that statisticians hope to exploit is the relatively low cost of perusing data, a procedure that may give the statistician a better understanding of the data being examined. Unfortunately, the speed with which microcomputers can support the

examination of large files of data on anything other than a case-by-case basis may be so slow as to preclude the use of an interactive approach in data analysis when large numbers of records or large files are involved.

General guidelines:

The interactive approach to computing, so well supported by microcomputers, is particularly useful in such tasks as data entry, word processing, certain planning and management functions, and computer program development. When small data files are involved, this approach is useful as well in data editing, generation of reports, and statistical analysis.

When large numbers of records must be processed (as in table production) or uniform and well-documented editing of a data file is required, batch processing is an appropriate approach, even on microcomputers. Many computing jobs would benefit from a skillful combination of the two approaches to processing.

## 13.3 Data Formats and File Structures

Data stored for use on mainframe computers has typically been recorded in either ASCII or EBCDIC character codes on a medium such as magnetic tape. Although many file structures are used in mainframe computing, the simplest and most common form of the computer record has been the fixed-length, fixed-field format in which a record consists of a string of ASCII or EBCDIC characters. The position of characters within the string is used to distinguish one field of the record from another. This format has proven to be functional and efficient for the storage, processing, and transfer of large quantities of data.

Microcomputers work with ASCII codes. Software to translate ASCII to EBCDIC code is available, but it is not commonly used. In addition, COBOL, FORTRAN, and Pascal compilers for microcomputers use, or at least accept, a fixed-length, fixed-field record format and others similar to those used on mainframe computers. BASIC, on the other hand, uses an idiosyncratic data format employing variable length records and fields separated by a delimiter such as a comma or a blank. A record that is treated in BASIC as a string of characters is delimited by a pair of quotes ("), and it is not unusual for a limitation of 256 characters to be placed on the size of the string. Another file format used by a number of application software packages is known as the Data Interchange Format (DIF).

The traditional fixed-field format has many advantages, even on the microcomputer. First, it may be easily maintained through the use of a text editor, such as WordStar. Second, it is likely to simplify attempts to pass data between a mainframe and a microcomputer. In addition, a number of significant software packages such as dBASE II, ACCESS/80, and SL-Micro are capable of using fixed-field records without modification. In contrast, it is difficult to access data stored in a BASIC format with programs that have been written in languages other than BASIC (and, on

occasion, even with programs written in another version of BASIC). For example, if data are keyed using a program such as MICROSTAT which relies upon MBASIC, any later attempts to examine or process the data file using programs written in FORTRAN or packaged software that was not designed for use with BASIC data files would require that the data file be reformatted. This reformatting process, while technically straightforward, is time-consuming and often problematic and is well worth avoiding. There is nothing inherently unsatisfactory about the BASIC data storage format, however, and, if all processing on a particular file can be done with BASIC programs, there is no reason that it should not be used.

Relative and random access techniques are used to great advantage on microcomputers. Sequential access methods are supported, but indexed sequential is less common. Attempts to maintain hierarchical files will, in most instances, require that record types have a common length so that the relative or sequential access methods supported can be used.

General guidelines:

When several software packages will be used, select those accepting a common data format. Be prepared for situations in which data files will have to be reformatted to allow them to be used with other packaged software or with software written in different high-level languages.

The fixed-length, fixed-field record is a data format that will often serve well as this common data format, forstalling the need for time-consuming and potentially difficult format conversions. Avoid typical BASIC formats unless all or most programs to be used in processing are written in BASIC. Use sequential or relative access methods. Both are well-supported on microcomputers.

## 13.4 File Size

One of the more serious limitations often faced by the microcomputer user is the size of data files. File size will be limited by (1) the number of records that are allowed and (2) the capacity of disk files supported by the operating system or capable of fitting on a single device (such as a floppy disk). Files that exceed the capacity of a single disk drive are seldom allowed by an operating system. If we take CP/M 2.2 as an example, there is an absolute limit of 65,535 records for a single file. Larger data files would have to be broken up into separate files falling within this limit. In addition, since CP/M does not support files that extend over more than one volume, if the CP/M system has only floppy disk drives for data storage, the file size cannot exceed the capacity of a floppy disk, which is not likely to be more than 1.2MB. With the addition of a hard disk with sufficient capacity, the data file could be increased to the CP/M 2.2 maximum of 8MB.

In addition to these technical limitations on file size, there are practical ones as well. Software packages designed to work with files of modest size may not perform well at all when called upon

to deal with a large file. For example, attempts to use a text editor on a large file may fail when the text editor attempts to find an equivalent space on the disk storage device for recording a backup copy of the file or when the size of the file seriously degrades the package's performance. WordStar works well with files as large as 100KB, even though it may take some time for the editor to position itself at the end of the file. With files approaching lengths of 1MB, even the reliable WordStar package has difficulty and may require several minutes to reposition itself by even a few lines or records within the file.

General guidelines:

It is not reasonable in most instances to consider maintaining files of a size exceeding one-third to one-half the upper limit on file size imposed by the operating system to be used. For CP/M 2.2, this means no more than roughly 25,000 records or 3MB, when a hard disk with more than 8MB of storage is available. It may be necessary to break large data files into smaller parts to comply with this restriction.

## 13.5 Storage Media

Although relatively costly for the storage of large quantities of data, the floppy disk has proven to be a robust and reliable magnetic medium, and it continues to be the most common form of peripheral storage on small and inexpensive microcomputers. When the microcomputer is to be used for processing small files, the floppy disk will ordinarily be an entirely satisfactory storage medium.

The sheer number of different physical sizes and recording densities being used by floppy disk manufacturers makes it difficult to recommend the use of a single type of floppy disk. Capacity of the disk will be an important concern in many NSO microcomputer applications. Physical size is of less concern as long as compatibility can be maintained among the different microcomputer systems used in an installation where data or program transfer is to rely upon the floppy disk. The IBM 3740 format for 8-inch floppy disks was so widely exploited in the early days of microcomputing that it offers a degree of compatibility not equalled since by smaller disks.

The availability of communications and network software, together with the introduction of many alternate formats and disk sizes and the appearance of systems lacking access to drives employing the older format, has substantially reduced the need for disk compatiblity. In cases where disk compatibility is required, the IBM 3740 format still remains an attractive candidate when more than one type of microcomputer system is involved.

When large data files or large-scale program development activities are planned, the next level of magnetic disk storage, the Winchester disk, is likely to be desirable. The Winchester disk not only offers increased capacity but improved data access speed

as well. One of the fixed Winchester disk's advantages in situations where environment may be a problem is that the disk itself is hermetically sealed, protecting the disk surface and recording heads. This is not true of cartridge disk devices, although vendors claim that they have provided sufficient safeguards to protect against the problems that could be caused by dust and dirt entering the drive. The selection of cartridge Winchester disks ought to be considered only in cases where the microcomputer's physical environment is relatively clean and dust free. The Winchester's performance in situations where the power supply is bad is not well-documented; but it is a relatively fragile device, and it is likely to be more sensitive to power problems than is the floppy disk drive.

Magnetic tape, especially cartridge tape, may be useful for performing backups of data stored on Winchester disk drives, but its use for other purposes will be the exception rather than the rule. There may be situations, for example, in which a network of microcomputers should have access to a 9-track tape drive to allow for both inexpensive archiving of data and transfer of files to a mainframe or minicomputer system. The mechanical aspects of 9-track magnetic tape drives are frequently a source of maintenance problems, and the introduction of a tape drive into a microcomputer system will substantially increase the cost of both procurement and maintenance. Nevertheless, the 9-track tape drive may find its way into microcomputer installations on occasion.

Video cassettes currently offer another medium for Winchester disk backup that appears effective and reliable but slow. The optical disk, which is expected to be available within the next five years, promises to dramatically expand the microcomputer's storage capacity, and, if costs are reasonable, may soon become an attractive storage medium.

General guidelines:

The floppy disk is a reliable storage medium. It is entirely acceptable for data storage when data files are small or can be conveniently broken into units small enough to fit on a single disk. It may be suitable also when the number of disks required to store a data set that is to be accessed in a single processing task is not unwieldy (probably no greater than half a dozen disks). If the floppy disk is to be used as the microcomputer's primary storage device, it is advisable to procure at least two drives. Plan carefully for compatibility if the floppy disk is to be used as a means of data or program transfer between computers.

The Winchester disk is another useful storage device. Winchester drives provide faster access and greater capacity than floppy disk drives, but they are considerably more fragile. If file sizes are to exceed 500KB, or if the total operating system and program storage requirements of the system exceed 1/2 to 2/3 the capacity of a single floppy disk, or if speed of data access is important, a Winchester disk should be considered. When a Winchester disk is selected, it is important that provision be made for performing

routine backups of the disk contents, perhaps through the addition of a streaming tape drive.

Nine-track tape drives with start/stop capability should be considered exceptional and used only in cases where large amounts of data must be archived or transferred to a mainframe system and no other communications link can be formed.

13.6 Security

Plans for the use of a microcomputer should include plans for insuring the security of data that is kept on the system. Errors are made, files are corrupted, and disks do develop problems even under the best of circumstances. Some protection against this inevitability is important. The most basic of security operations is that of making and maintaining copies of important computer files. Microcomputer users should be made aware of the importance of this process and be given guidelines to follow in performing backups.

A backup copy, as well as a working copy, of all system software should be made as soon as purchased software is received. Original copies should be stored in a safe location. A printed copy of the contents of each disk or tape should be prepared and should be kept current for all backup disks and tapes.

Shared data files should be backed up at regular intervals by someone assigned this reponsibility. Careful documentation of the backup process should be maintained as well. The interval for performing backups of these files may be determined by considering the frequency with which the file is modified. At least two generations of file backups should be kept on separate volumes at all times.

Backup of files that are not shared may be left to the individual responsible for the files, if the file is of no unusual importance. Individuals should take care to perform backups of data files whenever changes are made. It is advisable to maintain several generations of backups of program development files or data files that are undergoing frequent modification.

When floppy disks are used for longterm storage of data and program files, they should be periodically copied to insure that the data remain intact. All magnetic media have a limited shelf life.

General guidelines:

Backup copies of all computer files should be made regularly and stored in a safe place. Floppy disks are acceptable for storing backups of small files, but they are expensive. Magnetic tape and video cassette cartridges provide a more efficient means of recording the entire contents of a large storage device such as a Winchester disk.

## 13.7 Dealing with Memory Limitations in Software Development

The history of mainframe processing demonstrates that a great deal of productive data processing work can be done on computers with small memories. Nevertheless, in large processing tasks, memory limitations of 48KB or 64KB may pose problems. Two of the more common methods of dealing with limited primary storage require the division of a complete processing task into smaller, logically independent parts. These program parts are then implemented in separate programs or in separate program sections.

Chaining, a process by which one program calls another program upon its completion, is one of the more common methods for combining a number of separate programs into an integrated whole. It is supported by a number of BASIC interpreters and other language compilers. Another common approach involves the use of program overlays. In this case, a small "root" program remains resident in memory and calls independent sections of code into a reserved portion of memory when the function performed by that code is required. The reserved section of memory is repeatedly overwritten as different sections of code are called. There are a number of Pascal compilers that support the use of overlays, an extremely useful capability when developing programs for use within small memories. Both approaches tend to slow processing speed.

General guidelines:

Memory limititations are typically dealt with by splitting large programs into smaller units. At times these smaller units can still be successfully integrated, but there are limits to what can be done conveniently. If it is anticipated that memory may be a problem, it would be best to plan to use a microcomputer system capable of supporting more than 64KB of RAM.

## 13.8 Dealing with Limitations in the Speed of Peripheral Devices

The speed of a microcomputer is very often bounded by the speed of data transfer to and from printers and secondary storage devices such as floppy disks, Winchester disks, or tape drives. In these cases, system performance can be improved by reducing the number of occasions on which data must be written to or read from disk or by interposing another, faster storage medium between the disk and the computer. The first of these two approaches can be accomplished in many cases by using relative or random rather than sequential access to data files. Sequential files require that all records be processed, if any one is to be modified. With relative or random access files the single record can be requested directly without the need for a time-consuming pass through the entire file, useful in programs for selective file editing or maintenance. Unfortunately, in the production of tabulations and most statistical reports, data files must be passed record-by-record and access methods other than sequential may reduce processing speed.

The second approach to improving the speed of data access utilizes RAM that is configured to look like a disk drive. This type of

"memory" drive, available for a number of microcomputer systems, is extremely fast, and its cost is steadily decreasing. Files that are heavily used may be copied from disk to the memory drive, then written to or read from the memory drive in processing, and, finally, returned to the disk through a copy operation. The memory drive's one major disadvantage is that it is volatile and can be quickly and completely erased by a short power failure or an accidental power-down. A reliable power source is required for its use.

The speed of a character printer will also be noticably slow. For those who are used to mainframe computer processing with its copious and quickly produced printed output, the microcomputer printer may appear a serious limiting factor. Fortunately, the microcomputer's CRT display and its interactive operation go a long way to relieving the demand for printed output. Former mainframe users quickly adjust to the new situation by learning to direct most printed output to the CRT or by storing it on disk for later examination with a full-screen text editor. In almost every case it will be advantageous to use the disk as an intermediate storage device for printed output so that it is possible to decide whether the output merits being printed or not. Use of the disk also makes it possible for print spooling software to be used, so that printed output can be produced when the machine is otherwise unoccupied and unattended. An operating system that supports concurrent print spooling operations, or a hardware print spooling device, is a highly desirable option, since time-consuming print operations can then be performed while the computer is in use in other productive tasks.

General guidelines:

Microcomputers are slower than most mainframes, especially in performing batch operations. If speed of processing is important, select a microcomputer system that has been shown to have superior speeds in benchmark testing. A microcomputer's performance can be further improved by the addition of a Winchester disk or a memory drive. If printing speed is a problem, invest in a line printer and utilize print spooling hardware and software.

## 13.9 Communication with Other Computer Systems

One of the microcomputer's most appealing aspects is its stand-alone capability, its ability to do a complete computing job without support from other computers. The cost of the microcomputer makes it possible to consider dedicating a computer to a particular task, such as the processing of a survey or data entry for a foreign trade project. In its stand-alone operation, it may be free from the demands of many users and the organizational problems that come with managing systems that serve many projects. Even stand-alone systems, however, have a need to communicate with other computer systems at times. Software that is not developed on the system must be brought from another computer; data that are collected and processed on one machine may later need to be processed or available on other computer systems.

Preparations for the use of microcomputers, therefore, must include plans that deal with the question of how this communication will be accomplished.

The floppy disk has served as a primary medium of communication among microcomputers from the earliest days of microcomputing. To this day, microcomputer software is sold on floppy disks and the availability of packaged software is limited in part by the compatibility of floppy disk drives and formats between systems on which the software was developed and on which it is to be used. If careful plans are made for use of the floppy disk as a means of communication, the floppy disk can serve as an inexpensive and reliable medium for transferring data from one computer system to another. Drives must be selected for compatibility; and software necessary to deal with formatting differences must be procured if different operating systems are involved. In situations where systems are separated by considerable distance and telephone communication is non-existent or unsatisfactory to support the successful use of a modem, the floppy disk, or some alternative magnetic medium such as cartridge tape, may be the only alternative available.

In situations where telephone service is adequate or systems are in close enough proximity for a cable to be run between them, a modem may be used to support communication. Modems normally support relatively slow transmission rates of 300 to 1200 baud (approximately 30 to 120 characters per second), and they should be considered as the primary source of communication between systems only when data and program transfer are expected to be occasional. Software and hardware support for asynchronous communication is abundant and should be considered essential equipment if a modem can be used.

If communication among computer systems must be frequent or fast, and the systems are not separated by great distances. a local area network will provide the most appropriate communication support. Local area networks for microcomputers provide extremely high transmission rates and make it possible to bypass the problems of disk and operating system incompatibilities, if the network supports a variety of systems.

General guidelines:

The floppy disk may serve as a means of communication among computer systems, but it can do so only when care is taken to insure the compatibility of disk drives and disk formats. Unfortunately, the profusion of disk sizes, recording densities, and formats has severely limited the floppy disk's usefulness in this way. It is essential to plan for compatibility when any magnetic media is to be used for transfer of data among computer systems.

Asynchronous communications via a modem or a direct connection between two computers should be planned and provided for when

possible. Packaged software supporting this form of communication is widely available.

When data transfer among computers is to be frequent or voluminous, use of a local area network should be considered.

# CHAPTER 14: PUTTING MICROCOMPUTERS TO USE IN A DEVELOPING COUNTRY NATIONAL STATISTICAL OFFICE: A MYTHICAL IN-DEPTH CASE STUDY

Previous chapters have dealt with microcomputer applications in general; guidelines for selection, integration, and use of microcomputers; and thoughts on hardware and software for NSO applications. This chapter will look at how these issues relate to the typical situation described in Chapter 2. It will describe the phased introduction of microcomputers to answer the needs of various applications in a mythical NSO.

## 14.1 Goals for Introducing Microcomputers

The fictitious NSO realized that its mainframe computer would be antiquated and insufficient to meet its needs within several years. A collective decision was reached to look at microcomputers as an eventual replacement for the IBM 370/115 mainframe computer.

The most demanding task the NSO faces is the decennial census, which was still 4 years away. The biggest problem in the last census had been delays in data entry and an inordinate amount of time needed to edit the data using a batch system. The staff realized that they would have to obtain more data entry stations of some sort and expressed a preference for microcomputers over conventional data entry stations because of their greater utility after the census processing was completed. However, they emphasized the need to make a careful appraisal of microcomputers to be sure they could perform as needed for the census.

Data analysts were making numerous requests for crosstabulations, frequencies, and other simple statistics on existing data. These requests occupied much of the programmers' time and added to the turnaround problem by overburdening the system. Distributing microcomputers to the various departments for use by analysts themselves was seen as a way of freeing up programmer time, giving the analysts faster response, and diverting work from the central machine.

Everyone realized that program development using punch cards was not efficient. They looked at the interactive program development environment of microcomputers as a way of getting away from cards.

The NSO had many activities that were being done clerically, such as calculating budgets, updating personnel records, and producing graphic material for publications and speeches. Microcomputers offered them the chance to computerize many of these activities in a way that was both effective and efficient.

## 14.2 Priority of Applications

The NSO looked at potential applications for the microcomputer and ranked them in priority order based upon exigency, size, organizational importance, and cost/benefit. The resulting list was the following:

- -- Small survey of establishments,
- -- Foreign trade with emphasis on distributing processing to port sites,
- -- Administrative data base for personnel division,
- -- Word processing,
- -- Graphics,
- -- Budgets,
- -- Statistical analysis,
- -- Demographic census processing,
- -- Computerized sample frame, and
- -- Continuing household sample survey.

## 14.3 Request for Technical Assistance

The NSO staff realized that they knew very little about microcomputer technology and felt they needed advice on how to proceed. They requested technical assistance through an international donor agency to obtain the services of one or more consultants to assist them in selecting hardware and software and in learning how to use it.

A microcomputer expert was identified to supply the required technical assistance. The consultant planned to make a series of visits of up to 1 month each in duration.

## 14.4 System Requirements

The consultant reviewed the goals and priorities developed by the NSO prior to his arrival. He then worked with staff members to determine requirements for one or more microcomputers to be obtained. This effort resulted in the following requirements:

- -- The microcomputer must be able to write an 8" floppy disk readable by the IBM 370/115 in order to provide communication with the mainframe computer.

- -- The microcomputer must be able to read an 8" floppy disk produced by an IBM 3742 data entry station in order to make use of the existing data entry equipment.

- -- The microcomputer must allow for the integration of a 9-track tape drive to enhance communication with the IBM 370/115.

- -- The microcomputer must be able to be configured in a personal computer network (PCN) to facilitate communication with other microcomputers.

- -- The microcomputer must have both 8- and 16-bit capability to maximize the availability of packaged software and machine capability.

- -- CP/M-80 and CP/M-86 must be available for the 8- and 16-bit microprocessors, respectively.

-- FORTRAN and COBOL must be available, preferably on the 16-bit microprocessor.

-- Statistical software must be available for the system.

-- Other software, including word processing, spreadsheet, and data base packages must be available.

-- The system must be expandable to at least 512KB of memory in order to accommodate large programs and data sets.

-- It is preferable tha' the manufacturer be locally represented; however, if not, a clear means for providing maintenance must be identified.

-- The hardware and software must be fully integrated by the same vendor.

The consultant's first visit was a learning experience for staff members. He spent several hours each day just going over various aspects of microcomputing, demonstrating many points on a small portable microcomputer which he had brought along.

## 14.5 System Selection

Staff members accompanied the consultant to visit the few local microcomputer representatives. They included Apple, Radio Shack, Osborne, and IBM, although IBM did not yet have any of their Personal Computers in stock. Significant data were recorded on each system.

A careful evaluation of the system features, in terms of how they related to the goals and system requirements, indicated the IBM Personal Computer (PC) over the others. The major reasons for this choice included the following:

-- IBM was represented locally and two technicians were currently being trained in PC maintenance.

-- A number of software packages were already available for the IBM PC and more were being developed or converted.

-- The IBM PC could be made to run both CP/M-80 and CP/M-86.

-- The documentation for the IBM PC appeared to be quite good. (The vendor had a copy of the documentation despite not having a system.)

## 14.6 System Configuration

The consultant made an important suggestion regarding system acquisition. He recommended complete redundancy in the initial procurement, implying two complete systems, although some components on one machine would be more powerful than those on the other machine. He also suggested an incremental approach to the

technology, whereby two fairly basic systems would be acquired initially, to be upgraded and augmented in the future. He urged the use of a personal computer network instead of a multiuser system so as to avoid system degradation and to avoid concentrating too much work on a single system which could fail.

The initial hardware to be obtained included the following:

-- 2 IBM PC's, each with 256KB of memory and a Z80 board;

-- 2 8" floppy disk drives and 1 5-1/4" floppy disk orive on each system;

-- Color graphics board;

-- 20MB Winchester drive on one system, 5MB Winchester drive on the other system;

-- Top-of-the-line dot matrix printer on one system, standard Epson printer on the other system;

-- UPS on each system; and

-- Networking hardware.

The initial software to be obtained included the following:

-- CP/M-80 and CP/M-86 operating systems;
-- CBASIC-86, MBP COBOL, FORTRAN-80, and Pascal/MT+ 86;
-- WordStar;
-- dBASE II;
-- SuperSort;
-- ACCESS/86;
-- SL-Micro; and
-- Networking software.

## 14.7 Procurement

The Ministry of Finance had obtained a microcomputer during the previous year. A meeting was arranged to determine what steps had been followed for procurement and subsequent passage through customs. This exchange of information was quite useful in that Finance had learned several lessons during the course of obtaining the equipment. One suggestion was to include with the procurement forms a compelling written justification for obtaining the microcomputer which presented its potential benefit to the national interest.

Discussions with the local IBM representative brought out their reluctance to attempt any customization of the PC. It was decided that the safest means of obtaining the networked systems without serious problems was to allow the local representative to supply the basic systems and the consultant's firm to integrate the hardware and software utilizing identical basic systems, with the

understanding that the local representative would provide maintenance and support and supply future systems.

The consultant departed once the procurement paperwork had been submitted. He would not return until the systems had been integrated and burned in for at least 72 hours to assure their stability. It took roughly 6 months for the completion of the procurement cycle.

## 14.8 Installation

The equipment was not terribly heavy or voluminous. For these reasons, it was brought into the country by the consultant as excess baggage in order to avoid excessive delays in customs. As it turned out, the equipment was confiscated as the consultant entered the country, and it was necessary for a cabinet level minister to intercede in order to regain possession of the hardware. This process took 1 week.

Space had been provided for the microcomputer systems in a small area adjacent to the IBM 370/115. The room had been cleaned and an air conditioning vent had been cut to bring in cooling from the existing air conditioning system. This was not absolutely necessary; however, the summer heat might have been detrimental.

Within a matter of hours the systems were functioning correctly. The consultant was relieved that none of the components had been damaged in transit.

## 14.9 Initial Training

The next 3 weeks were devoted to learning how to use the equipment. Everyone attended the course on basic use of the machines and the operating systems. Selected individuals from among the data processing staff were instructed in the use of the various language processors and packaged software over the 3-week period. Training consisted of a balance of formal instruction and actual hands-on experience.

The following week was devoted to answering remaining questions about the hardware and software and preparing for an actual application. When the consultant departed, he was confident that the staff were capable of doing useful work on the systems.

It was decided that one of the systems would be indefinitely reserved for training purposes and for overflow from other systems yet to be obtained. In this way, it could remain truly redundant. It should be noted that the only way redundancy could be assured was to refrain from using the second system. Otherwise, a problem such as a power surge could disable both machines.

## 14.10 Applications

### 14.10.1 Application: Small Survey

The first application to be attempted was a small survey of 500 establishments which collected responses to 25 questions from each. This was a perfect application for dBASE II, the data base management package obtained. A dictionary was set up to conform to the questionnaire. The data were entered using the screen prompts provided by the package. dBASE II commands were written to edit data for out-of-range and inconsistent values. A list of corrections was created manually in order to document changes made to the data. Frequency distributions were then produced using SL-MICRO. The data were passed to the mainframe computer on a floppy disk in order to do some crosstabulations using COCENTS.

This application was revolutionary in that the entire process was completed in 3 weeks, and that included time to make some mistakes! It would previously have taken 3 weeks just to write and "debug" the program to edit the data. It pointed up the utility of packaged software where the data conform to the constraints of the package.

### 14.10.2 Application: Foreign Trade

Processing foreign trade data had always proved problematic. The data were notoriously bad and cycles of corrections were always needed. Combined with delays in turnaround, this meant that results were not timely.

The staff decided to make several changes to the foreign trade system. Data entry would be redesigned to provide formatted screens and a degree of editing. This would go a long way to solve the problem of shifted data and incorrect codes. They hoped the data entry could eventually be done at the customs house where the forms originated. Instead of writing new editing software at least initially, they decided to download and convert the COBOL programs being used on the IBM mainframe.

Implementing this system was a much greater challenge than they had faced in processing the economic survey. The data entry program was written in Pascal by programmers who were novice Pascal programmers; there was a lot of learning involved. They used WordStar for editing programs during the program development and testing phase.

The downloaded COBOL edit and correction programs were not difficult to convert to conform to the MBP COBOL compiler. The only problem was the frequent use of the STRING and UNSTRING verbs in the edit program; these verbs are not implemented in MBP COBOL. A routine was written to handle those cases which had used the verbs in question.

With the foreign trade application, as well as with each of the applications attempted, the intent was not to abandon a working

mainframe software system (wherever one already existed), but rather to run in parallel for as long as was necessary to assure a smooth transition. In this case, once the software system for the microcomputer was fully developed and tested, it was used to handle 1 week of foreign trade data entry in parallel with the mainframe system. (All tabulation and subsequent analysis was left on the mainframe.) It proved superior in terms of catching most errors at data entry time and was considerably faster because it alleviated the need to search for so many documents for manual review of edit rejects.

A decision was made to procure two additional systems, each with 20MB Winchester disks for foreign trade data processing. One would be used at the major port; the other would be placed on the network in the central office and serve as a backup to the port system. If the system in the field failed, the one in the central office could quickly be sent out as a replacement. Other customs sites would receive microcomputers over time.

Until good tabulation software for microcomputers became available, it was decided that crosstabulations and final analysis would be done on the mainframe. The data were simply passed to the mainframe on floppy disk.

The foreign trade application was considerably more time-consuming because of the need to write custom software. In that regard, it was a good contrast to the survey application. It was educational because it pointed up some of the strengths and problems with using higher level languages on microcomputers.

14.10.3 Application: Administrative Data Base

The Personnel Office of the NSO had been using a manual system for maintaining employee records. The records were never up to date because of the difficulty in making changes. Furthermore, employee folders often disappeared and had to be recreated. It was a major undertaking to provide simple statistics on the NSO employees, as were sometimes requested by the Director's Office.

A review of the data maintained indicated that they could be reduced to fewer than 32 variables per employee, thus allowing the use of dBASE II. The speed and ease with which the data could be updated and queried quickly convinced the Director of the need to put a microcomputer in the Personnel Office. It was a standard IBM PC with a 10MB Winchester disk and an Epson printer.

14.10.4 Application: Word Processing

The NSO produces voluminous reports on its various activities which require a considerable amount of typing and retyping. The clerical work was heaviest in the Director's Office.

It was decided that an additional microcomputer system would be placed in the Director's Office on the existing network to provide word processing capability using WordStar. This system would be

primarily for word processing, whereas the other systems thus far installed would provide word processing capability, but as a secondary function. For this system, a letter quality printer was obtained. A 5MB Winchester disk was provided to enhance the system's speed.

The Director's secretary and her assistants felt comfortable using the microcomputer within a week's time. The Director was amazed at how quickly his reports and speeches could be revised and finalized.

14.10.5 <u>Application: Graphics</u>

The Director began to think of other things the new microcomputer might do for him and wondered about providing graphics capability for use in his presentations.

All of the applications thus far attempted had made use of variations of hardware and software obtained in the initial two systems. Graphics, on the other hand, introduced the need for a color monitor and a user-friendly graphics package.

The consultant previously used was requested to make recommendations for the necessary hardware and software. He was asked to assure that the software could interface with CP/M files produced by custom programs, alleviating the need to enter all the data through the graphics package. It also needed to be able to produce pie charts and bar charts with adequate labels.

Because graphics capability was not necessary in the short run, the Director was willing to buy only one color monitor. He had to realize that if it became disabled, his graphics would have to await its repair.

The consultant identified a graphics package that met the criteria as stated above and found a monitor with acceptable resolution and color representation. He brought the hardware as accompanying baggage on a return trip and it was quickly operational.

14.10.6 <u>Application: Summary Statistics of Economic Census</u>

Processing of the National Economic Census had recently been completed on the mainframe computer and volumes of tabulations had been produced. But the Director had found that his professional colleagues were totally unwilling to search for answers to their questions in the reams of paper he showed them.

He requested the preparation of a diskette of various summary data from the census in a format compatible with the new graphics package. At his next presentation he was able to quickly display bar charts showing distribution of types of establishments, pie charts depicting income by economic sector, and line graphs illustrating trends for economic expansion. He had found a convincing way to make his points understood.

### 14.10.7 Application: Departmental Budgets

The preparation of budgets had always been done in the style of individual departments of the NSO. It was nearly impossible to reconcile differences caused by this individual approach. Furthermore, budget preparation was an activity everyone dreaded because of the tedium of adjusting all the figures numerous times.

The Director was so pleased with his successes in word processing and graphics that he advocated obtaining a spreadsheet package to assist in preparing budgets. He felt that the whole process could be significantly simplified and far more palatable.

He decided to acquire the SuperCalc package and put it on the microcomputer in the Personnel Office, since it was not being used full time. He assigned his assistant the task of learning how to use it (with the help of the data processing staff) and coordinating the input of the department heads. Everyone was amazed at how quickly the individual budget components could be modified to reflect changes in salary scales, overhead rates, commodity prices, or other factors.

### 14.10.8 Application: Statistical Analysis

Analysts from various departments were constantly making requests for simple crosstabulations, frequencies, and other statistics. This often took a considerable amount of time on the part of the programming staff.

They decided to take a new approach. Where feasible, they would prepare summary data files, using COBOL to extract the data, and teach the analysts how to use ACCESS/86 to obtain the desired statistics. Time on two different microcomputers was made available to analysts wishing to participate in this effort. It proved successful in freeing up programmer time and gratifving to the analysts who now sensed a greater familiarity with the data and felt free to explore it in more depth.

A variance program written in FORTRAN for the mainframe was downloaded to run on the microcomputer. It ran slowly but correctly after the records were broken into pieces to conform to limits of the FORTRAN compiler.

### 14.10.9 Evaluation

The elapsed time from the decision to obtain one or more microcomputers was now 24 months. The overall reaction to the introduction of microcomputers had been favorable. It was a good time to evaluate what had been accomplished and where the process was going.

Thus far, six microcomputers had been obtained by the NSO: five were networked in the main office and one was being used at the major port. A variety of software had been obtained to meet the needs of the different applications attempted, among them a small

economic survey, a revised foreign trade system, an administrative data base, word processing, graphics, spreadsheet generation, and statistical analysis.

The hardware procured had been successfully integrated into computing environment. It could communicate with the mainframe computer as well as with the existing IBM 3742 data entry devices by using 8" floppy disks. This latter capability was important to the NSO since it had just completed payment for this data entry equipment. Thus, they could continue to be used for straightforward keying.

The consultant had been a key component of this institutionalization process, providing initial advice and guidance in system selection, supplying integrated systems, giving training in the use of the hardware and software, and consulting by telephone when problems arose. The fact that the same person had been involved over the entire time period had been an added bonus.

Very few hardware problems had occurred. The local IBM representative was able to provide timely maintenance, consisting primarily of adjustments and board-swapping. One EPSON printer had had to be returned to the factory because it could not be repaired. The IBM representative loaned the NSO an identical printer during the time it was being repaired. They had acquired enough duplicate components to be able to do this for "preferred" customers.

The regular activities of the NSO had continued with no apparent interruption during this time of microcomputer introduction. The staff size was augmented by three positions to handle the additional work. This could be justified by the elimination of positions in the Personnel and Foreign Trade Offices. (These people were reassigend to fill clerical vacancies, which would otherwise have been filled by hiring persons from the outside.)

It is interesting to note that the possibility to use microcomputers served as an attraction to bright, young candidates. Hiring had previously been much more difficult.

The morale of the data processing staff had improved significantly during the 24-month period. They were excited about using a new technology, about learning new programming languages and techniques, and about getting away from a batch environment that was completely out of their control.

The networked system proved quite effective. A malfunctioning microcomputer could be easily removed from the network without affecting the other microcomputers on the network. Data files could be quickly and easily transferred between users. In addition, files could be transferred and printed on the faster printer when necessary.

The staff had become familiar with virtually all of the software obtained. The preferred language had become Pascal, although BASIC was frequently used for small tasks, and COBOL and FORTRAN provided

a means for mainframe software conversion since these compilers existed on both the mainframe and microcomputer systems. The packaged software was adequate to meet the needs for which it had been procured.

Expenditures to date totaled roughly $100,000 broken down into $60,000 for hardware; $10,000 for software; $25,000 for consultation; and $5,000 for maintenance and supplies. It is difficult to quantify the impact of the microcomput'rs on efficiency and timeliness of data. Several of the people from outside agencies who viewed the Director's graphics presentation asked the NSO to do reimbursable work which provided added revenue. In addition, program development in an interactive mode without the use of punch cards allowed programmers to work more efficiently. However, as long as the mainframe was still being leased, the cost would definitely be higher than it was previously. The phased introduction of microcomputers would have to be viewed as a cautious investment in the future of the NSO.

The data files processed to date had been modest in comparison to the size of a demograhic census. Attention now turned to focus on the potential for microcomputer use for processing the census data.

14.10.10 Application: National Census

The national census of housing and population was still 2 years away. But plans were quickly being finalized and a pretest was scheduled for a year prior to the actual census.

During the past 2 years, mark sensing devices had proven to be a reliable means of data entry which greatly expedited the data capture process. Those who had originally advocated the use of interactive, screen-oriented data entry now began to wonder whether the use of mark sensing equipment in conjunction with microcomputers might be more effective.

They examined it from an economic point of view. Two mark sense devices at a cost of $50,000 each plus a document slitter (to separate multiple-page questionnaires into single sheets) at a cost of $10,000 would suffice for the entire data entry effort over the period of a year. (The mark sensirg devices would not be fully occupied during this period, but would be processing data in work units as they came from the coding staff. Two machines were necessary for redundancy.) Each of these would be hooked to a microcomputer with a 20MB Winchester disk and a 9-track tape drive, costing $16,000 per system. This was opposed to the need for 20 additional microcomputers and two tape drives at a total cost of $210,000. Obviously, mark sensing seemed to be a sound decision from an economic viewpoint.

There would be certain similarities between the data keying and mark sensing approaches. The data would be treated in work units, based on geographical coding. The data would be stored in packed binary format in order to maximize the use of space. The data would be transferred to the mainframe computer on standard 9-track

1/2" magnetic tape, where they would be sorted and then edited using CONCOR and tabulated using CENTS 4, packages yet to be acquired.

There would be some significant differences betweem the two data entry approaches. The data captured by mark sensing would be edited only for gross errors such as unintelligible codes or duplicate codes. If none of these was found, the data would be written to disk. Clerks with no special knowledge of the data would be capable of doing the data entry. However, keying the data with interactive editing would perform a significant degree of data cleaning prior to sending them to the mainframe computer. In addition, clerks would have to be more highly trained to respond to edit problems. Significantly more would be involved in the latter system, with the necessity of incorporating error diaries to reflect changes made to the data.

In weighing the arguments for and against it, mark sensing was deemed to offer greater efficiency at a lower cost than keyed data entry. The success with the IBM Personal Computer recommended its use in either alternative.

For purposes of the pretest, the NSO decided to purchase one mark sense reader, one additional microcomputer system, and one tape drive. A potential problem arose when it was learned that the initial systems obtained were no longer available. On further examination, one of the current models was compatible to a large degree with the older model and could satisfy the needs of the census. Because there was no local representative of the mark sense reader company or the company which manufactured the tape drive, and the previously used consultant was from the same country, he was contracted to provide the interface with the IBM PC. Within 6 months he arrived with the new hardware and installed it.

The microcomputer system appeared to function correctly. The only problem was that the tape it produced was unreadable by the mainframe computer. The consultant made a lot of telephone calls and tried several "fixes" before he was able to produce a readable tape.

Mark sensing had several implications for other aspects of the census plans. A high grade of paper had to be used. The questionnaires had to be printed in a special format to conform to the requirements of the mark sense reader. The interviewers had to be carefully instructed in how to record responses and in physical care of the questionnaires. The coders had to receive similar instruction.

The pretest consisted of 5,000 households. The data were recorded and put on tape as they came from the coding section over a period of two weeks. In actuality, the mark sensing equipment was only operated for a total of 8 hours during this period, and there very very few rejects. The rejected questionnaires were instructive to



## 15.17 Sierra Leone

As in the case of Jamaica in 1981, the U.S. Department of Agriculture provided a North Star microcomputer for Sierra Leone

the interviewers and coders. The tape was passed to the mainframe where it was processed without any problem.

Before the actual census, an identical system was obtained for redundancy. Census processing was relatively smooth. The only problems occurred when several batches of questionnaires were put through the mark sense reader twice, and when an entire work unit had been damaged by water and could not be read; it was necessary to manually transcribe that batch.

The entire census was processed in less than 18 months, a record for a country which had taken 4 years to process the previous census. The NSO began to look for other uses for the mark sense equipment.

Meanwhile, one of the original microcomputers was placed in an office where the need for statistical analysis had grown to warrant a microcomputer for their exclusive use. One of the statisticians learned BASIC and enough about the microcomputer to be able to work quite independently.

## 14.11 More Microcomputer Power

The mainframe computer had been very slow in running the editing and tabulation software to process the census. In speed comparison tests, the Motorola 68000-based microcomputers ran faster than the IBM 370/115. These microcomputers now had enough software available to warrant their consideration as a replacement for the mainframe. This software included generalized packages for editing and tabulation which were the equivalent of the U.S. Bureau of the Census' CONCOR and CENTS 4 packages. Connecting a tape drive was not a problem.

The NSO carefully evaluated 68000-based machines and chose one which was represented locally and could insure compatibility with their existing microcomputers via diskette and tape. In addition, it could be put on the network if desired. Once again, two machines were procured for purposes of redundancy. In addition, the day-to-day workload had gradually increased since the distribution of computing power began.

Eight months after the installation of the new microcomputers, the NSO felt secure in giving up its mainframe computer. All major systems had been converted and were running smoothly. Although the new 68000-based machines had a different operating system, those staff members who had been using microcomputers for some time had no trouble in learning to use the new hardware and software.

## 14.12 Distributed Processing

In several years the NSO had gone from a centralized computer facility to a widely distributed system of computing. Everyone now had access to two 68000-based microcomputers. The computer center staff had three IBM PC's, one of which had a tape drive. The Foreign Trade Office had put a microcomputer at each customs site

and had one microcomputer with a tape drive in the central office. (Only final editing and tabulation were done centrally.) There was an IBM PC in the Personnel Office, the Director's Office, and in an office doing statis ical analysis. The mark sense readers had been disconnected and re awaiting use in the upcoming agriculture census.

Redundancy was everywhere and people were no longer fighting for priority. One staff member did nothing but deal with user questions and problems, but things ran fairly smoothly. This may have been largely a result of the incremental change to a different computing environment.

14.13 Future Applications

In addition to its routine data collection efforts, the NSO wanted to set up a continuing household capability program. This would involve computerization of a sampling frame and processing a moderate amount of data on a regular basis. It would be important to plan a system that could easily keep up with the incoming data. NSO staff were sure microcomputers could handle the job!

14.14 Final Note

It should be noted that the process described above is in direct response to a particular situation and would certainly differ for another set of variables. For example, there is no universal justification for replacing mainframe computers by microcomputers. It is simply a matter of looking at the capability, cost, and use of the mainframe in making a recommendation. Furthermore, the use of IBM PC s by this mythical NSO in no way recommends this microcomputer for all NSO's. In the case presented, the IBM PC simply met more of the selection criteria than any other microcomputer. It is important to bear in mind that each case is unique and must be approached in a systematic, but individual, way.

# CHAPTER 15: CASE STUDIES

Microcomputers are being used successfully for diverse applications. The examples that follow are representative of statistical applications being done on microcomputers today around the world. The contact cited in each case is the source of most of the information presented.

## 15.1 Bangladesh

The mainframe computer at the Bangladesh Bureau of Statistics (BBS) was destroyed by fire in the summer of 1980. A small pilot survey of industry in Dhaka was left unprocessed as a result. In the interim of getting a new mainframe computer it was proposed that the data be processed on an Apple microcomputer owned by two U.S. economic statistics advisors to the BBS. The data consisted of 800 records with 100 fields per record. The data were entered, edited, and tabulated using the package DB Master. During the course of the processing one disk drive had to be repaired, but using the remaining two drives caused no problem. Apple Juice, a form of uninterruptable power supply (UPS), was also disabled at one point. During this time data loss due to power outage was experienced. Producing tabulations using DB Master proved to be very time-consuming, requiring up to 6 hours for a single tabulation of the Dhaka pilot data.

Overall the experience was positive despite the problems encountered. The initial goals were accomplished. Those involved felt that the potential for this type of processing would be greatly increased if a package specifically designed for entry, editing, and tabulation were available.

Contact: Bob and Laurie Torene, DHAKA, Department of State,
Washington, DC 20520

## 15.2 Bermuda

Data processing on the island of Bermuda is centralized in the Government Administration Building. They have an IBM System 38 mainframe computer. Three years ago they began acquiring microcomputers to supplement the mainframe capability. Initially an NCR 2950 was purchased. Then four Apple microcomputers were procured. Whereas the NCR produced diskettes capable of being read on the System 38, the Apples did not. So a Micromation machine was acquired to convert Apple diskettes to run on the System 38. At some point in time a Cromemco microcomputer was purchased, and more recently the United Nations has provided a Motorola 68000-based Cromemco. The biggest problem they face is one of incompatibility. The System 38 is incapable of being directly connected to any of the microcomputers and a variety of operating systems are represented. This is largely the result of not having an overall procurement strategy. The NCR and Apples are currently being used for cash receipting, an important activity for an island which depends on the tourist industry. The Micromation is serving as a development machine and a machine for word processing. The

Cromemcos are being used in water projects. In the future, they have chosen to stay with microcomputers capable of running CP/M. They have identified specific statistical requirements in the government which need the power of 16-bit microcomputers.

Contact: William Petrie, DP Controller, DP Unit, Government Administration Building, Hamilton, Bermuda

## 15.3 Bolivia

The statistics office in Bolivia has four Ontel microcomputers. They are used primarily for word processing. In addition, they use these machines for a consumer price index application, for which they enter price data and run some simple BASIC programs to calculate indices and produce a report. In general, the Bolivians are not happy with the Ontel microcomputers because they are slow, archaic, and limited in capability. They will soon acquire 8 DEC VT180 intelligent terminals to relieve some of the workload on their DEC 20/20.

Contact: Jorge Teran, INE, Plaza Guzman Aspiazu #1, Casilla de Corres #6129, La Paz, Bolivia

## 15.4 Cameroon

Cameroon is seriously studying the impact of rapid population growth on its development by using an Apple II+ microcomputer and software developed under an AID funded program known as RAPID (Resources for the Awareness of Population Impact on Development). The study, which was recently presented to Prime Minster Bella Bouba and other senior Cameroonian officials, demonstrated that, if current trends continue, Cameroon's current population of 8.4 million would more than double by the year 2010 and almost quadruple by the year 2025. This exponential rise in population would be likely to seriously hinder Cameroon's ability to achieve its development goals.

RAPID was designed by the Futures Group with the goal of promoting awareness among developing country policymakers of the relationship between population growth and socioeconomic development through presentations to planners, senior government officials, and heads of state. The presentations employ an interactive computer monitor and color displays on a television screen to vividly highlight the impact of populaton growth on the achievement of national development goals. The analysis includes the effects of population growth in various socioeconomic sectors such as urbanization, agriculture, energy, employment, health, and education. The interactive model helps stimulate debate among alternative demographic scenarios. To date, RAPID presentations have been made in 33 countries, including Cameroon, Nigeria, Tanzania, Burundi, Rwanda, Senegal, Mali, Upper Volta, Malawi, Swaziland, and countries in the Middle East, Asia, and South America.

Because of the interest evoked by the RAPID presentations, the Cameroonian government has expressed renewed interest in the

establishment of an AID supported population unit in the Ministry of Economy and Plan. Establishment of the population unit would constitute the first step toward the creation of a National Population Commission first proposed by President Ahidjo in 1980.

Contact: John Stover, Manager, Analytic Services, The Futures Group, 76 Eastern Blvd., Glastonbury, CT 06033

15.5 Cape Verde

In Cape Verde two brands of microcomputers, both running under the OASIS operating system, are being used to process the national census of housing and population. Five Billings microcomputers were installed by the United Nations in 1981 for the purpose of entering the data. The total data volume will be between 20 and 30 million bytes (300,000 - 400,000 people). An Onyx system C-8001/MV was procured the following year to handle data editing and tabulation. The Billings and Onyx microcomputers communicate via a "send and receive" communications package developed for linking OASIS systems.

A potential problem exists in the fact that the company that produces the Billings microcomputer may be going out of business. The fact that several boards have been sent for repair and have not been returned does not bode well. However, the software developed for the Billings machines will run on any OASIS system. Therefore, even if the hardware becomes unusable, the software effort can be salvaged.

Both in Mauritania and in Cape Verde, the United Nations has taken responsibility for procuring and maintaining the equipment. There has been a full-time United Nations expert in-country for the duration of the processing. This fact may be largely responsible for the relative success of both of these microcomputer applications. It remains to be seen how these microcomputers will be used after the applications are completed.

Contact: Luis Silva Rendall, Director, Direccao de Recenseamentos e inqueritos, C.P. 162, Praia, Cabo Verde

15.6 Cook Islands

The statistics office on the Cook Islands acquired an Altos microcomputer in 1980 through UNDP/UNFPA. They are running the CP/M operating system, as opposed to other Altos supplied by the United Nations which are using the OASIS operating system.

The Altos system is used for a variety of applications. These include the population census, import and export statistics, and employment and wages surveys. The machine is fully occupied and is apparently the only computer used by the statistics office.

The operation of the system is relatively free of problems. No significant maintenance has had to be performed. Memory and speed

have not posed a problem. Although there are power fluctuations, they have not been serious enough to warrent backup power supplies.

Contact: A.M. Turua, Statistics Officer, P.O. Box 125,
Rarotonga, Cook Islands, South Pacific

### 15.7 Ecuador

In 1982 the statistics office in Ecuador obtained 9 Alpha Micro microcomputers, primarily for processing their national census data. Each microcomputer can accommodate eight users, dividing the 256KB equally to give each user 32KB.

They approached the new equipment very sensibly. In November they received training from the local Alpha Micro representatives. Then they used the microcomputers for entering data from an agricultural statistical survey as a means of further training. After 4 months they were ready to begin actual census processing.

The microcomputers are being used for entering and doing preliminary editing of data for 8 million people. The data are initially recorded on diskettes and are subsequently concatenated on magnetic tape for transfer to a mainframe IBM computer. The data then undergo editing using the CONCOR package on the mainframe. The ultimate phase is tabulation on the mainframe.

The programs for data entry and editing on the microcomputers were written in BASIC. Programs for initial tabulation on the microcomputers were written in assembly language to enhance their speed. Alpha Micro representatives assisted the statistics office in software development.

The Ecuadoreans are pleased with the performance of their microcomputers. This application is especially noteworthy because it was well planned and is largely the responsbility of the statistics office staff, as opposed to projects with extensive expatriot assistance.

Contact: Alberto Moyano Cevallos, Chief of Data Processing INEC,
Av. 10 de Agosto #229, Quito, Ecuador

### 15.8 Francophone Africa

In Upper Volta and in other African countries, 16 researchers from the School of Agriculture of Purdue University are utilizing several Radio Shack TRS-80 microcomputers primarily to enter data "in the field" and to run some elementary statistical analysis of the data before shipping the data to Purdue for further analysis and tabulation. The Purdue staff learned a great deal from their experience; and, during the first two years of the 4-year project, the Purdue researchers made several improvements and necessary modifications to their original procedures. Many of the changes were due to technology improvements. For example, the data storage medium changed from cassette to diskette when diskettes became readily available on TRS-80 systems. The project data manager

noted a 50% improvement in interactively edited data entry speed under the diskette-based system. Other changes, such as standardizing encoding and data entry procedures across all questionnaires and making all field procedures as user-friendly as possible, were instituted to facilitate final processing at the Purdue computer center.

The project data manager for the Purdue project foresees the inevitable increased distribution of microcomputers in government offices in the West African countries. (In fact the project has installed a micro in a government office in Dakar). He also believes that microcomputers with increased capabilities will permit complete data analysis in-country entirely by microcomputers. The focus of the Purdue project has been on getting the results for the researchers in the best way possible. While the "best" way means, in theory, keeping the data near the source throughout processing (for verification, if necessary), the practical solution to getting any research results (in a timely manner) meant shipping cassettes and later diskettes to the U.S. for processing. Institutionalization, that is, leaving behind a working data processing system, was not of primary interest to this research project.

Contact: Len Malczynski, Consultant, 5279 Elmer, Detroit, Michigan 48210

## 15.9 India

The statistics office in India has been using two Indian microcomputers, the HCL-8C and the DCM-SPECTRUM-7, since 1980. Their primary usage is for processing the 34th and 36th rounds of the National Sample Survey, consisting of a total of 145,000 records. Because of memory limitations they have had to divide the data into many work units and repeatedly run the programs involved. The slow speed of the machines had been a problem. They use a battery back-up system to combat frequent power outages, but this does not completely solve the power supply problem. They have changed their approach to editing and updating files as a result of their experience with microcomputers.

Contact: Dr. S.N. Ray, Director, Data Processing Division, NSSO, 25-A, Shakespeare Sarani, Calcutta-17, India

## 15.10 Indonesia

Four Osborne microcomputers are being used to do entry and preliminary editing of data from a two-round survey in Indonesia. The survey, undertaken by Johns Hopkins University and the Helen Keller Institute, is studying the effect of using vitamin A to prevent a potentially blinding eye disease among 30,000 children. Data are collected at the village, family, mother, and child level, generating roughly 300 bytes per child. Approximately one third of the total data entry effort has been completed. Government people were trained in the use of the Osbornes and Helen Keller representatives are supervising their efforts. A program to do

crude tabulation of the data from several diskettes is being installed as a means to assess "reasonableness."

The data are being sent to Johns Hopkins for further processing on a large IBM mainframe. The diskettes are loaded into an Osborne and transmitted to the IBM system using the software package Crosstalk.

The power supply is quite variable in Indonesia. A voltage regulating isolation transformer was purchased in Jakarta and installed on the four Osbornes.

Two maintenance problems have arisen. The first was a fuse which was blown as the result of a sudden change in voltage. The problem was diagnosed over the telephone by someone in the United States; however, the Osborne repair station in Indonesia charged $80 to replace the fuse. The second problem occurred when one of the four Osbornes obviously malfunctioned upon arrival. It was taken back to the United States for repairs.

The data entry system set up using the Osborne microcomputers has been surprisingly trouble-free. More importantly, the initial data appear to be of high quality.

Contact: Stephen W. Singer, Suite 101A, 550 N. Broadway,
Baltimore, MD 21205

15.11 <u>Jamaica</u>

In 1977 a decision was made by the Jamaican Ministry of Agriculture to conduct a quarterly Crop Production Survey because of the country's need for objective statistics on crop yields, estimates, and forecasts of crop production. The processing system was implemented on an IBM 370/135. Because of heavy utilization, the turnaround was so slow that the data were usually made available too late to be of great use.

In 1979 the U.S. Department of Agriculture (USDA) gave the Jamaicans a North Star Horizon II microcomputer under the Remote Sensing Project. The original configuration had 64KB RAM and a printer terminal. In addition, USDA provided a series of BASIC programs to enter, edit, summarize, and analyze the data. This was the beginning of a system that has since been significantly refined by USDA. The Jamaicans have written programs to crosstabulate the data and to further enhance the system by allowing easy deletion of data values and addition of information and corrections to the data file. Over the years the original system was upgraded to provide multiuser capability.

The North Star is fully utilized each week. The major production applications include:

-- Crop Production Survey consisting of 4,500 records (600 variables x 5 bytes) conducted every 3 months.

-- Comprehensive Rural Township Development Programme consisting of approximately 370 records (350 variables x 5 bytes) run every 45 days over a 9-month period.

-- Pig Census consisting of 10,000 records (160 variables x 5 bytes) collected annually.

The use of the North Star has not been without problems. They have dealt with frequent diskette failures by keeping backup copies of all files and software and by buying reputable brands of diskettes. A good power conditioner has improved equipment performance. A new version of the multiuser operating system significantly improved program execution. The CRT's were set at 9600 baud to try to overcome the slow response time experienced under a multiuser environment.

The North Star system is fully institutionalized in the Jamaican Ministry of Agriculture. Although it has taken several years to sort out problems and maintenance problems still exist, the Jamaican experience is an excellent example of the successful use of a microcomputer for statistical applications in a developing country.

Contact: Beulah Edoo, DP Manager, Data Bank and Evaluatior Division, Ministry of Agriculture, Hope Gardens, Kingston 6, Jamaica, West Indies

15.12 Kenya

In mid-1980, the Kenyan Ministry of Agriculture and the Ministry of Livestock Development faced serious financial problems in the budgeting process, in tracking expenditures, and in the billing of donors. A team from Stanford University's Food Research Institute was asked to explore the use of microprocessors for a number of activities within the two ministries. The most immediately relevant activity identified by the team was in the area of budget and finance.

The Apple II+ was selected for use in this country because of the large amount of software available, the Apple's relatively high tolerance of power fluctuation, and the presence of many other similar machines in the country. The system includes 64KB of memory, a monitor, a printer, and two disk drives.

Microcomputers are now being used to:

-- Improve the expenditure reporting system;
-- Facilitate decisionmaking in situations where budget over-expenditures threaten to occur;
-- Promote improved budget estimate processes; and
-- Facilitate better data collection and reporting on programs and projects which are donor-funded.

The microcomputer has been used successfully in several other areas within the two ministries. First a study of the grain sector was

conducted by a consultant and involved the computation of trends for every maize-producing district in the country. A regression program was used to check the work of the consultants and provide the Ministry of Agriculture with its own tests of the consultant's assumptions. Second, for the ongoing negotiations for an international tea agreement, a proposal for determining market share was modelled using VisiCalc. Members of the negotiating team examined how Kenya's market share changed by changing negotiable items, and discovered the relative importance of items. Finally, the graphics capability of the microcomputer was used to create bar graphs and charts for a series of talks on the Kenyan agriculture sector.

In the short term future, the ministries plan to use the microcomputer for vehicle control and word processing. Longer term uses include project monitoring and early crop forecasting.

Contact: Dr. Carl Gotsch, Gotsch Associates, Inc., Palo Alto, California

## 15.13 Mali

Mali is the site of a very ambitious AID-sponsored project to study infant mortality. The University of Pennsylvania is participating in an 8-round survey over a 2-year period which began in April 1981. It will follow 5,000 children and generate several million data points. The data entry and initial editing and analysis are being done in Mali using four IBM Personal Computers and custom software written in BASIC. After the initial entry and analysis, the dikettes will be sent to the U.S. to be put on magnetic tape for further analysis. Every attempt will be made to support analysis in Mali; however, the only computers available are older, are not readily accessible to social scientists, and have no analysis software.

The IBM Personal Computer was designed to run at 110V. Since the current in Mali is 220V, it was necessary to devise a way to meet the power requirements. The machines use a car battery charger and a converter for this purpose.

The University of Pennsylvania has been quite pleased with the work done to date and they are convinced of the practicality of this approach. They are currently trying to obtain money to train more foreign students in the use of microcomputers.

Contact: Dr. E. Van de Walle, University of Pensylvania, Population Studies Center, Graduate Group in Demography, 3718 Locust Walk Cr, Philadelphia, PA 19104

## 15.14 Mauritania

Two Altos microcomputers with the OASIS operating system were purchased by the United Nations for processing data from a fertility survey in Mauritania. The Altos microcomputers are used in conjunction with an IBM 370/125 mainframe. Entry and editing of

the 160,000 records (30 characters per record) are done on the Altos; tabulation is achieved on the mainframe. A program to convert OASIS files to IBM diskette format (and vice versa) was purchased for the purpose of exchanging data between the microcomputers and the mainframe.

Problems occurred in getting the equipment through customs, in printer integration, in maintenance, and in power supply. The microcomputers were delayed in customs for over a month for administrative reasons. There was some difficulty in adapting the Texas Instruments printer to produce the French character set which includes accents not used in English. Maintenance is being handled by sending components out for repair. The turnaround time is estimated at 120 days, which implies long delays in getting repairs done. The power supply is so bad that they have resorted to using a generator, working nights when the power is better than normal, changing to less sensitive disk drives, and using a Topaz line conditioner.

The use of the Altos microcomputers with the IBM mainframe is a good example of successful integration of microcomputers in a mainframe environment. The microcomputers are fully utilized in the tasks assigned to them, leaving further processing to be done on the mainframe.

Contact: P.W.P. Browne, Interregional Adviser in Computer Applications, United Nations, Room CH 5202, New York, NY 10017

15.15 Nigeria

The Agricultural Projects Monitoring, Evaluation, and Planning Unit (APMEPU), based in Kaduna, Nigeria, has introduced microcomputers in a distributed environment to handle agricultural processing. Fifteen Apple II microcomputers are being used on a regional level for data entry, validation, and analysis.

In the late 1970's, it became increasingly clear that existing computer facilities at Ahmadu Bello University, Zaria, were inadequate to produce timely agricultural statistics. Furthermore, a software bottleneck grew up as programming staff were faced with the difficulties of operating in Zaria while based in Kaduna.

This caused a complete rethinking of the approach to data processing which resulted in the decision to introduce multiple microcomputers for data preparation and initial analysis. The Apple II was chosen because it is flexible enough to serve the needs of a wide range of potential users. The flexibility of the computer with its associated peripheral hardware has enabled the same units to be used across various application areas including data collection, word processing, and spreadsheet generation, while the modularity of the equipment allows for easy maintenance and optimum use of peripherals.

The following four surveys have been or are in the process of being computerized on the Apple:

- -- Agronomic Analysis Survey. An average survey consists of 1200 field/plot records. The Field/Plot Report and Household Report are the most important outputs.

- -- Clearline Survey. This is the latest of a series of farm management surveys, which collects weekly data on items such as crops, fertilizers, and labor utilization over a 1-year period. Nearly 6,000 survey forms are involved.

- -- Price Survey. This survey takes a periodic look at current market basket price. It is the simplest of the surveys undertaken.

- -- Baseline Survey. This survey attempts to detail farm size, ownership, household composition, off-farm activities, cropping patterns, farm inputs, livestock holdings, and asset ownership for a large number of households. The status of this application is unclear.

A definite attempt has been made to design forms which facilitate direct coding and interactive data entry. Furthermore, all programs are designed to communicate with the user interactively in a meaningful manner.

Training is provided for systems developed in-house, as well as for WordStar, VisiCalc, and VisiPlot. Training is generally conducted at the site office of the project using the survey. A typical training session for the Agronomic Analysis Survey lasts about 2 weeks, during which time personnel are instructed on how to use the microcomputer system, enter data, and produce the required reports.

APMEPU staff have a supply of spare boards and chips which allows them to perform most minor repairs within a day's time. If the hardware must be sent back to its source in the U.K. for repair, the user is provided with a replacement unit in the interim.

The APMEPU project is significant because of the large number of microcomputers involved, and the fact that data are being processed in a timely manner, whereas the processing had almost stopped prior to the introduction of microcomputers. Issues of training and maintenance have been sensibly approached.

Contact: Derek C. Poate, APMEPU, PMB 2178, Kaduna, Nigeria

## 15.16 Puerto Rico

The Technical Services Division of the U.S. Bureau of the Census has implemented an experimental microcomputer-based data entry and editing system to be used in the processing of the Puerto Rican Economic Census. This census polls 26,000 establishments; each questionnaire may have up to 1,000 responses. Once data entry and

the initial phase of data editing have been completed in San Juan, the data will be brought to Washington for further processing.

Omninet, a CORVUS personal computer network, links ten Apple II+ microcomputers with four central 20MB Winchester disk drives. Keyers at each of the 10 stations can work with records stored in a shared file. A telephone connection allows Bureau staff in Washington to work directly with the network as it is set up in San Juan.

The Pascal p-System was used for program development. All software for use in data entry and editing was designed and coded in-house. Three programmer years of effort were required to complete the system which includes general purpose file hashing and screen handling utilities as well as programs to support the specific tasks of data editing. Record access is extremely fast and includes a record lockout feature that prevents the handling of any record by more than one of the ten microcomputer stations at a time. The system designers and implementers won U.S. Department of Commerce awards for their innovative work.

The large size of the census dictated the need for several data entry stations so that data entry could be completed in a timely manner. Apple II+ machines were chosen due to their inexpensive cost, their relative stability (after many years on the market), the availability of the UCSD p-System and their compatibility with the CORVUS Omninet network. Networking was judged important to the success of this project because it made possible the development of a single on-line data base that could be shared by all of the individual workstations. The large quantity of data involved in the survey raised problems for both the transfer of data from San Juan to Washington and for file backup. The CORVUS Mirror system provides a video recorder capable of backing up the contents of a single 20MB CORVUS disk in just over 1 1/2 hours. The video tape is used not only for backups but also for transferring data and programs between Washington and San Juan.

Maintenance problems were anticipated and provision was made in procurement for an additional Winchester disk to be kept in Washington until a need for it arose. A similar but smaller network installed in Washington supported program development and provided additional redundancy for the Apple II+ systems and network hardware in Puerto Rico. Replacements for those elements of the network that might fail were to be flown to San Juan the next working day while the faulty part was returned to Washington for servicing.

The system provides an excellent example of a network of stand-alone microcomputers devoted to a single task. The success of the system was due in part to precise and complete definition of the tasks that were to be accomplished by the microcomputer system before design or procurement were begun.

Contact: Paul Friday, Technical Services Division, U.S. Bureau of the Census, Washington, DC 20233.

## 15.17 Sierra Leone

As in the case of Jamaica in 1981, the U.S. Department of Agriculture provided a North Star microcomputer for Sierra Leone under the Remote Sensing Project. A Peace Corps volunteer with a strong data processing background was recruited to oversee the computerization of agriculture survey data on the North Star.

The original plan was to process 20,000 records (of 30 bytes per record) during 1982 and 7,000 records during 1983. Unfortunately the data collection has bogged down. However, several rounds of the survey were processed successfully.

Personnel and hardware problems have been difficult. Only recently was a host-country counterpart assigned on a permanent basis to work with the Peace Corps volunteer. Power problems caused significant equipment damage. The initial Elgar high isolation transformer is being replaced by an Elgar AC line conditioner, costing $3,000. This is the equivalent of a UPS without the battery. The IDS 560 printer has had to be shipped back to the U.S. for repair several times.

Board and chip level diagnosis and maintenance are being handled successfully in Sierra Leone using a supply of spare boards and chips. This saves a significant amount of time and money over sending components out for repair.

Although the North Star in Sierra Leone has been productive, it has not been as fully institutionalized as the Jamaican North Star. This may be a factor of time. However, it is significant that the Jamaicans very early on took over the responsibility for their project, whereas that transfer has not yet been completed in Sierra Leone.

Contact: Jamie Brown, PCV, Peace Corps, Private Mail Bag,
Freetown, Sierra Leone, West Africa

## 15.18 Singapore

The Department of Statistics in Singapore obtained an Apple II+ in 1981. It is currently used by 20 statisticians as a general purpose machine, although analysis and research applications predominate. They have had to break up large programs because of memory restrictions, and they have experienced a problem with the slow speed of the machine. They purchased an Apple largely because of local representation and the availability of many software packages. Despite its slow speed, the Apple has afforded a three-fold savings in time for work that was formerly performed manually. Their goals are to computerize more applications that are currently done manually and to set up in-house training to enable more staff to use the microcomputer for their work.

Contact: Miss Wu Wen Chee, Senior Statistician, Department of
Statistics, P.O. Box 3010, Singapore 9050

## 15.19 Tunisia

From 1979 to 1981, a team of three faculty members from Cornell University set up a "Rural Development Information System" in Kasserine, Tunisia, which was based on a dual system of Apple II microcomputers. Their mandate was to work with a team of planners from the Central Tunisian Development Authority.

They conducted an "informant" survey in 80 subdistricts within Central Tunisia and processed the data using a package called ISIS, which was written by Fernando and Sandra Bertoli. This package was important because it simplified the use of the computer and made it possible for everyone, after minimal training, to access the data. Moreover it permitted the use of the computer at various levels. Finally, it permitted statistical analysis in the simple form of cross tabulations and the more complex form of multiple regression. ISIS provides for subtitles in English, French, Spanish, or Arabic.

The Institutionalization of the Cornell effort was not completely successful. They did leave behind two Apple II microcomputers with a set of disk drives, a monitor, and a printer for each. They provided training in the use of the ISIS package and in trouble-shooting system problems. However, their Tunisian counterparts were not as receptive to their training as they might have wished.

Nevertheless, Cornell sees microcomputer technology as an appropriate element to decentralized administration of rural development. They are concentrating on developing a set of microcomputer modules dealing with different problems which make practical uses of the type of data collected in rural development projects.

Contact: Dr. Frank W. Young, Cornell University, Department of Rural Sociology, Warren Hall 34, Ithaca, NY 14853

## 15.20 United States

Westat is a private company in the United States which does all aspects of survey data collection, processing, and analysis. They purchased over 20 Apple II microcomputers to supplement a VAX minicomputer and an IBM mainframe computer. They chose Apples because of their cost and their prevalence. They rely on packaged software to the extent that it is available to support their specific applications; they use BASIC and Pascal where packages are not appropriate.

They undertake a wide variety of applications, including receipt control with an optical character reading wand, direct data entry, computer-assisted telephone interviewing, management information for telephone surveys, and statistical analysis. They use packaged communication software to facilitate communication between the microcomputers and the larger computers.

Contact: David Morganstein, Westat Inc., 1650 Research Blvd., Rockville, MD 20852

15.21 Various Countries

The International Fertility Research Program (IFRP) has requests from all over the world to transfer computer load programs, standard table programs, and other software in support of clinical trial data and maternity care monitoring. They experienced numerous problems in attempting this transfer to a variety of mainframe computers. After a careful study, they chose to adapt their system to run on Texas Instruments (TI) DS990 microcomputers. A major criterion for the selection of TI was the high visibility of TI offices in developing countries. The prototype system was installed in Tunisia, Indonesia, and Thailand. There are requests from 50 other countries for similar systems.

From IFRP's point of view, the use of microcomputers in high volume research centers and clinical institutions presents the following immediate advantages:

-- A significant reduction of staff effort devoted to the transfer of technology.

-- The pooling of data in-country and among groups of countries and the addition of clean data in a uniform format to the IFRP mainframe computer (Burroughs B6700) on a worldwide basis.

The IFRP holds some of the largest sets of computerized clinical records in the world. They feel that the use of interactive micrcomputers will greatly facilitate the archiving and retrieval of such data around the world.

Contact: Ed Whitehorne, International Fertility Research Program, Research Triangle Park, NC 27709

15.22 United Nations (Various Countries)

The United Nations has probably had more experience in using microcomputers in developing countries than ny other international organization. The following dialog is excerpted from an interview with two UN staff members (X and Y) who have been heavily involved in the UN's microcomputer applications.

Q: How did the UN first come to recommend microcomputers?

X: We decided to recommend microcomputers because we were dealing with small countries in which there were absolutely no alternatives. There were no suppliers that would go into these countries, the microcomputers were cheap, and they were capable of being supplied in multiples which allowed redundancy; and so we decided to try it. We first did population census applications. The countries we dealt with all had populations of between 80,000 and 400,000 people.

Y: I really don't think anybody is completely confident in the technology to support statistical data processing because even with the new super microcomputers, the software is still pending. But, then again, if we look back at the minicomputers we were using 6 years ago, like the NCR 8250, our first microcomputers were more powerful than those machines.

X: If you compare a microcomputer with an NCR 8250, I'd rather have the microcomputer. It's more powerful and more useful. So it was a gamble, but it was a gamble we had to take.

Q: Upon what did you make your decision as to which microcomputer to place in a particular country?

Y: Well it's easy on the issue of Altos because X found that years ago OASIS software was so far advanced over anything else available on the market that that dictated what machines we were going to use, in a way. In some countries we needed multiuser capability which Altos provided along with a hard disk, a 30MB 14-inch Winchester which is now obselete but at the time was very nice. OASIS was written for Altos among others and was the first machine to really function well in a multiuser environment. So that dictated those choices. As for Cromemco, we ended up in Rwanda with Cromemco because the University in Butari had one. We were under the impression that the Canadians who were helping them establish a computing program within their university had trained nationals in the maintenance of Cromemco equipment. That information turned out not to be entirely true. But at any rate, based on that information, we continued with Cromemco because it was the obvious choice in light of maintenance. We did not need multiuser capability at that time for the projects we were supporting in Rwanda. We continue to use OASIS software, but now almost entirely purchase ONYX multiuser microcomputers, both 8- and 16-bit systems, to run it on.

Q: Why have you not chosen a "standard" system?

X: We like to meet user needs and it turns out that you can't use the same thing over and over again in different countries to meet all user needs. We probably ought to approach more of a standard or multiple standards than we have been using but this is an infant industry and the desirability of these various choices changes in our mind over time, sometimes quite quickly. So in a sense, we've been experimenting with different kinds but, in another sense, we've tried to make each choice fit the user needs as we perceive them.

Q: What would have been the chance for success without long term UN advisors at the site of the microcomputer applications?

X: Zero!

Y: Definitely. I second that soundly.

Q: What has happened after projects have terminated and UN advisors have departed?

X: I think all our projects are still ongoing. We haven't had a project dependent upon microcomputers terminate yet. I think there's a real problem as to how well these operations will function without the assistance and support of expatriates in the country. They don't have to be UN staff. They can be bilateral, they can be people that are living in the country, but I don't think microcomputing is going to take off, especially in Africa, without that kind of support.

Q: What has been your experience with power supply and what would you recommend?

X: We started out measuring power by means of a fairly sophisticated power line monitor. In Cape Verde, for example, which was the first place we used this technique, we found really quite stable power over a reasonable period of time and as a result we didn't protect the equipment very well. A year or two later when we installed the ONYX hard disk based system, the electrical generating plant had some major problems which caused the destruction of both hard disks. They weren't really destroyed, they had to be shipped back to the United States for maintenance but, in effect, it shut down the census operations for several months. So we underestimated, or perhaps I underestimated, the degree of fluctuation or severity of power problems in countries like those in Africa and I think now we really have to protect this equipment. I would think of putting UPS's in almost all African countries and maybe in other countries also.

Q: How do you feel about the OASIS operating system you originally supported? What about the alternatives that now exist?

X: I still think it's a very good operating system but I'm really distressed with several things. First, they've been promising FORTRAN for 3 years and it's increasingly apparent that they may never deliver it. It's not of much importance to their market which they see as the small business system market in the United States. We need FORTRAN for a lot of our work. Second, even though it's a really good operating system, the amount of software available for it is not growing as fast as for say CP/M, and there's a good possibility that UNIX will be an important operating system in some of our installations. So we're deviating from OASIS quite a bit. In fact, we haven't put an OASIS system in for a year or two and unless they get FORTRAN up and running, I'll be reluctant to put in any more.

Y: MP/M II was just released last summer and up until this release, MP/M was not a reliable operating system. It still is not a good operating system. It limits you to a very small user area, it's extremely unfriendly to its users, and it has many limitations compared to OASIS; compared to UNIX it has only a fraction of the power of hat operating system. So,

UNIX at this point, in spite of its terseness, is emerging rather rapidly as a temporary standard, but it could easily be surpassed by anything else.

Q: What is the possibility of getting some kind of central support for microcomputing activity?

X: Who's going to pay for it? This activity costs money and the kind of resources that you have to put into backstopping it are out of proportion to what you pay for backstopping a major mainframe. I don't know how USAID works, but typically the UN finances overhead support at the rate of 13% a year. 13% of one microcomputer doesn't buy you very much. 13% of a mainframe buys you a lot more. Furthermore, you probably have to put more work into supporting the microcomputer.

Q: Why would you have to put more work into supporting the micro-computer?

X: Because in the case of the mainframe, you're dealing with a manufacturer who's providing the support and you are essentially working through him. In the case of the micro, you're probably doing a lot of work yourself, including technical fact finding in New York and buying parts and shipping them out and so on.

Y: What is significant now is the development of new super microprocessors like the (Motorola) 68000 and the upcoming Intel iAPX286. These relatively new chips are running neck to neck with large minicomputers, yet the new super microprocessors come in small packages. They frequently cost less than $20,000 and at that price the manufacturers are in no position to give you the kind of support they give you when you pay from $80,000 to over $100,000 for the equivalent minicomputer. So, in spite of the fact that these machines look like a panacea for our processing needs overseas, on the other hand, they're posing incredible problems because they're just as sophisticated as a minicomputer and yet you have zero support in the field; so it really puts us in a much more difficult position in many ways.

Q: What experience have you had in establishing communications between microcomputers and mainframe computers?

Y: In two places it worked very well. The first effort was in Rwanda. One of our Cromemco single-user systems was installed at the National Computing Centre and it was connected to an NCR 8250. The NCR representative came around and found a spare asynchronous port that wasn't being used. It was designed to go to a teletype-like terminal so it had no particular protocol. We hooked up through that line. The data processing expert was able to develop programs in COBOL on the Cromemco and even test them to a large part, as the COBOL was somewhat similar to what the NCR was running. He was able to do some debugging on the Cromemco, which has a much more flexible

editor and a considerably faster compiler. When he was satisified that his ideas worked, he was able to upload the program text to the NCR, work out the small differences in COBOL, and recompile. That worked fairly well. The second place where we used communications was in Argentina, in a water resource development project just outside of Buenos Aires. We connected a multiuser Cromemco system running Cromix to an S120 Data General Eclipse. They had river water level data on 1/2-inch tapes, which were able to be read by the Cromemco. They used a more flexible database management system to manipulate the data and create their tables without having to write any programs. So that also worked out fairly well.

X: In both of these cases I'm struck by the fact that the microcomputer was more powerful in many ways than the minicomputer to which it was attached. In the case of Rwanda, the memory available in the Cromemco for program address space was twice that of the NCR.

Q: How do you envision microcomputers complementing mainframes in the NSO of the future?

Y: You can put a WICAT system, say their model 150, on your desk and have up to 4 million bytes of directly addressable memory in it; I don't know too many mainframes that would give you 4 million bytes to work in during the day. The WICAT is very fast. You could probably do more statistical work on a machine like that on your desk assuming you could get the data into it (which is a communications problem) than you could do on a mainframe.

Q: Do you see microcomputers as having any special advantage over larger computers?

Y: The Data General Eclipse in Buenos Aires could not address more than 64KB of memory per data array. The WICAT can address up to 4 millions bytes. There's not a minicomputer on the market that can address more than 128KB of memory without going into a virtual operating system such as the Data General's VS series which takes you into the 32-bit realm, but there's no mainline minicomputer that addresses more than 128K. Most only address a 64KB data area and then you have a 64KB program area. Some language processors of the new microcomputers that run the (Motorola) 68000 can directly address 4 million bytes, so right there you're way ahead of the minicomputers. Most mainframes, even though they can address tremendous amounts of memory, don't have the time or space to give you that kind of addressability unless they are dedicated to statistical processing.

Q: How adequate is existing software for doing statistical processing on microcomputers?

Y: You have to develop a lot yourself but once SPSS is available, I think things will begin to really take off (not that SPSS is

the end-all of statistical data processing, but it's such a standard).

X: There is a micro SPSS, SL-MICRO, from Questionnaire Service Company in East Lansing, Michigan. There's BMD and P-Stat for the WICAT. That's traditionally big system software. Other things will come. I think the key is the address space. Once you get 4MB address space, you can put lots of big system software in there and once you put (Motorola) 68000 or National semiconductor 16032, you have a fair amount of computing capability to make it work.

Q: What advice would you give an NSO contemplating the use of microcomputers?

X: You've got to have maintenance support in the country. I think almost every major mainframe manufacturer now has a microcomputer, whether they make it themselves or buy it. You've got IBM, ICL, NCR, and Burroughs, all which have microcomputers of various sizes and shapes. Some are better than others. If they're present in the country and are willing to offer support, then you don't have to worry about central support from UN New York or other such places.

Q: What are some of your most recent recommendations?

X: In Malawi we're using Burroughs Convergent Technologies machines in the planning office and ICL DRS 20's in the statistical office.

Y: The Burroughs machine is manufactured by Convergent Technologies and both Burroughs and NCR sell it. It's an 8086 multiuser machine that supports large hard disks, but it's a proprietary operating system and you're 100 percent locked into the vendor with it. The ONYX we're sending down to Guyana is the Z8000 machine using the Zilog 16-bit processor. It supports 7 users and comes with a 40 megabyte built-in Winchester drive. You can add several more 40 megabyte Winchester drives. It will be running UNIX System 3 (our first experience with UNIX in the field), and a very powerful information management product called INFORMIX.

X: In China we're probably going to be putting in at least a couple of small computers to help the Chinese to define the graphics for some unusual Chinese characters for their census printing. And in Egypt we're putting in three Bi-Telex machines based on Ontel components.

Q: What type of person is necessary to install a microcomputer in a developing country?

X: If you're talking about who can take one to the middle of nowhere and install it, Y can do it. I might be able to stumble through but I'm not sure. If you're talking about

being able to use one that's in an organization and is being supported, then anybody on our staff could do it.

Y: It's just that with the microcomputer, again, you don't have the manufacturer's representative to hook it up for you. If there are hardware problems and you don't have a hardware background, you are simply stuck and that's all there is to that issue.

Q: Have you had problems with equipment being damaged in transit?

Y: Everywhere I've been, by the time the freight arrives it usually is pretty awful to look at; it really gets beat up. But we've been lucky that there have only been minor problems, like chips being unseated on printer circuit boards, or maybe a printer circuit board cable being loose inside.

Q: What can you say about the documentation provided for microcomputers?

Y: Documentation ranges from excellent to absolutely horrible. IBM has set a wonderful standard for the industry with their operation and maintenance manuals for the PC and it seems that everybody who wishes to compete with them is following suit with that level of documentation.

Q: Is microcomputer technology raising more problems and questions than it is solving?

Y: No. Absolutely the inverse. It's challenging and turbulent, but it simply requires innovation. It requires imagination to pull out what's relevant and what's not.

X: Four years ago when we first thought about putting Billings Micro-Systems in Cape Verde, the computer industry was in an entirely different situation than it is today. Then, microcomputers were hardly even being used in small businesses. They were more in the realm of the hobbyist. They were just beginning to be used in small businesses. Now, 4 years later, every major manufacturer is either in the game for keeps, or is getting in the game, and you're beginning to institutionalize this microcomputer technology. It's an entirely different situation. We may be able to deal with established vendors and get the same kind of computing that we've gotten from the minicomputers and the mainframes at significantly lower cost. I think the advent of micros has opened up a lot of options that weren't there before.

Y: It's basically easy to buy a microcomputer, but then the user finds out that none of the software does exactly what he wanted and things don't connect together. Because it is a new industry, it requires somebody who has some experience to smooth out the rough edges.

Contact: George Sadowsky, UN Statistical Office, the United Nations, Room DC-2-1550, New York, NY 10017,

# CHAPTER 16: ISPC EXPERIENCE USING AN APPLE II+ MICROCOMPUTER

## 16.1 Choice of the Apple II+

As part of the microcomputer feasibility study, two microcomputers were selected for procurement and in-depth, hands-on testing. It was decided that one system would be used to test the full capabilities of microcomputers and be representative of the leading-edge of microcomputer technology; the second system was to be representative of those systems typically used in developing countries today. The tasks selected for processing on this second system included data entry, graphics, communications (including the transfer of files between computers), and evaluation of a statistical software package. It was to have an abundance of packaged software available, color graphics capability, BASIC and Pascal language processors, and a price tag under $10,000.

Given the criteria for the second machine, the Apple II+ proved to be the best selection. Of the microcomputer users surveyed, more than one-third indicated using Apple microcomputers. The closest to Apple was TRS. The Apple II+ has an abundance of software available, both proprietary and in the public domain. This became apparent when reviewing microcomputer periodicals such as Softalk, BYTE, and Creative Computing. Apple users groups also make available at a nominal charge a selection of public domain software to their members. Color graphics are available as a standard feature on the Apple II+. If the user connects a color TV or monitor to the system, color graphics can be generated. BASIC is also available as a standard feature. The DOS 3.3 Operating System is included when a floppy disk drive and controller are purchased. Apple Pascal is available for an additional $225. The Apple II+ with a 20MB CORVUS disk drive could be purchased for less than $10,000. There was no other microcomputer available that was as widely used overseas as the Apple II+ and that met the selection criteria.

## 16.2 Components of the System

The Apple II+ Microcomputer System purchased consists of the following hardware components:

- -- Apple II+ with 48KB of memory
- -- RAMCARD from Microsoft (provides an additional 16KB of memory)
- -- 2-5.25" 140KB floppy disk drives
- -- Apple III monitor (green screen)
- -- AMDEK Color I monitor
- -- CP/M card
- -- Videx Enhancer II video enhancer card
- -- Videx keyboard enhancer
- -- ABT numeric keypad
- -- Super Fan
- -- CCS Model 7710A asynchronous serial interface
- -- PKASO parallel graphics interface

-- CORVUS 20MB hard disk
-- NEC PC-8023A printer

The system also includes the following software components:

-- Apple DOS 3.3
-- Apple Pascal version 1.1
-- PTERM communications software
-- CP/M version 2.20B with MBASIC
-- ISIS
-- Apple II Business Graphics

16.2.1 Description of Hardware Items

The hardware procured in addition to the basic Apple II+ system was designed to enhance the Apple II+'s features and provide a more powerful and user-friendly system. This section describes the features provided by the Apple II+ system components.

16.2.1.1 Apple II+ with 48KB of Memory

The Apple II+ with 48KB RAM (Random Access Memory) is the basic system upon which all components are added. It contains the CPU for the system, which is a MOS Technology 6502 microprocessor running at about 1 megahertz. The 6502 CPU allows direct addressing of a maximum of 64KB RAM. The Apple II+ motherboard contains 8 slots available for insertion of additional boards. One of the 8 slots is reserved for an additional memory board. The other 7 slots can be used for plugging in a disk controller, communications interface, printer interface, and other types of boards. The CRT and the keyboard do not require the use of any motherboard slots.

16.2.1.2 RAMCARD with 16K Bytes of Memory

The RAMCARD from Microsoft provides the 16KB RAM necessary to bring the Apple II+ up to its full complement of 64KB RAM. Approximately 4KB of the 64KB RAM available is reserved for the Apple CRT.

16.2.1.3 Floppy Disk Drives

The System has 2-5.25" floppy disk drives. The floppy disk drives use single-sided, single-density, soft-sectored floppy disks. The disk drive controller board is set up to read or write 16 sector diskettes and software is available to read 13 sector diskettes.

Normally, the user would boot the system by placing an operating system diskette in a floppy disk drive and then turning on the machine. However since the system was set up to automatically boot from the CORVUS hard disk system, this is not necessary.

16.2.1.4 Apple III Monitor

The Apple III monitor was, as its name implies, originally designed for the Apple III microcomputer, however it can be used with an

Apple II+. It has a 12 inch green screen and good resolution for Apple II+ graphics without color. The screen displays 80 characters per line and 24 lines.

16.2.1.5 AMDEK Color I Monitor

The 13" AMDEK Color I Monitor provides a means of demonstrating and using the color graphics capabilities of the Apple II+. Both the Apple III Monitor and the AMDEK Color I Monitor can be connected to the Apple at the same time via the Videx Video Enhancer II component.

16.2.1.6 VIDEX Enhancer II

The Apple II+ system transmits an image to the CRT that allows only 40 characters from each line to be seen at one time. The user must utilize control keys to see the other 40 characters. The VIDEX Enhancer II card provides a means of viewing 80 characters at one time. It also provides an additional cable for a CRT which allows both the AMDEK Monitor and Apple III monitor to be simultaneously connected to the System.

16.2.1.7 VIDEX Keyboard Enhancer

The VIDEX Keyboard Enhancer provides the Apple II+ keyboard with features it does not already have. It provides upper and lower case capability, a type-ahead buffer, and an auto-repeat and fast repeat feature. There is also a facility allowing for the macro definition of special characters by the user.

16.2.1.8 CP/M CARD

The CP/M card provides the hardware necessary to allow the Apple II+ to run under the CP/M operating system. It contains a Zilog Z80A CPU which can access all the Apple II+ memory and peripherals.

16.2.1.9 ABT Numeric Keypad

The ABT Numeric Keypad provides the Apple II+ with a standard 10-digit numeric keypad to assist in numeric data entry.

16.2.1.10 Super Fan

Since the Apple II+ System has many peripherals and a large number of controller boards, the Apple II+ chassis can generate a large amount of heat. High temperatures are dangerous for electronic equipment. The Super Fan provides an air current for cooling the Apple II+.

16.2.1.11 CCS Model 7710A Asynchronous Serial Interface

The CCS (California Computer Systems) Model 7710A provides an RS-232C interface which is used for communications. The CCS 7710A

Interface is connected to a Bell 212A modem via a specially wired RS-232 null modem cable.

16.2.1.12 PKASO Parallel Graphics Interface

The PKASO interface provides a parallel port for the NEC PC-8023A printer. PKASO is an intelligent interface that can change the number of characters per inch, characters per line and other characteristics for the NEC printer. Graphics images on the CRT can be printed on the NEC printer via the PKASO interface.

16.2.1.13 CORVUS Hard Disk

The CORVUS hard disk provides high-speed on-line storage for up to 20MB of data. The Apple II+ can be booted from the CORVUS hard disk. This is different from most Apple systems which are booted from floppy disk. The CORVUS hard disk was set up with Pascal, CP/M, and DOS operating systems.

16.2.1.14 NEC PC-8023A Printer

The NEC PC-8023A is a dot matrix impact printer with a 10" carriage. It can print up to 100 cps and has graphics capability.

16.2.2 Description of Software Items

There are three operating systems available for the Apple II+. These are DOS 3.3, Apple Pascal Version 1.1 and CP/M Version 2.20B. This section describes these operating systems and the other sofware purchased.

16.2.2.1 Apple DOS 3.3

DOS 3.3 is the standard Apple II+ operating system. The operating system is supplied on a floppy disk which also contains several utilities and games that run under DOS.

16.2.2.2 Apple Pascal Version 1.1

Apple Pascal is the Apple II+ implementation of UCSD Pascal with extensions for graphics and other functions.(1) It is a menu-driven operating system with many powerful utilities. The Pascal compiler available is a pseudo-compiler which generates p-Code (pseudo-code). The system is contained on four floppy disks.

16.2.2.3 PTERM Communications Software

PTERM is a communications software package for the Apple II+. It may be used to establish communications between the Apple II+ and any other computer. Files may be transmitted or received using PTERM, or the Apple II+ can be treated as a terminal. All files received are saved in Pascal text format.

16.2.2.4 CP/M Version 2.2B with MBASIC

CP/M (Control Program / for Microcomputers) is a very popular operating system for microcomputers. There is a wide variety of software available for CP/M and a large amount of public domain software. The CP/M software accesses the CP/M card described earlier. CP/M as implemented on the Apple has a 56KB limitation instead of 64KB since 4KB is reserved for the screen and another 4KB is not addressable. Along with the standard CP/M utilities, CP/M also comes with MBASIC, a BASIC interpreter from Microsoft.

16.2.2.5 ISIS

ISIS (Interactive Statistical Inquiry System) is a statistical package developed by Information Systems International for the Apple II+. It runs under DOS and provides a facility for survey data entry, simple editing, and reporting.

16.2.2.6 Apple II Business Graphics

Apple II Business Graphics provides a means of generating pie charts, barcharts, and line graphs on the Apple II+. The graphs can be produced on the Amdek Color I monitor or on the printer.

16.3 Assembling the Apple II+ Microcomputer

Although our procurement contract specified that the awarded vendor "provide for the acquisition and assembly of an integrated Apple II+ microcomputer system...," this was not the way in which the system arrived. The Apple II+ system was received with each component in its original shipping box. After discussions with the vendor, we decided to assemble the system on our own. The assembly of the complete Apple II+ system spanned more than a month. This lengthy time period resulted primarily from:

-- Requested components not being in the vendor's stock. The vendor had to special order or otherwise await delivery of some system components.

-- One system component was not compatible with another. Although we discussed the specific components of the system with several vendors, none indicated the potential for incompatibility.

-- Some system components were DOA (Dead On Arrival) or were faulty or out of adjustment. One cable was missing and another was not included as part of the system.

Although these problems were the major cause of delays in assembling the Apple II+ system, there were a number of problems that slowed down the process. These included:

-- Inadequate tools for assembling the system.

-- Poor installation instructions, or incorrect instructions for certain system components. Some instructions offer trouble-shooting hints, but these were often useless.

-- Our inexperience with assembling and using the microcomputer equipment.

Although the process of integrating the Apple II+ system required more than a month, the system was actually usable within the first two hours of the assembly process. All that is required to run Apple DOS 3.3 is the basic Apple II+ connected to a video monitor and one disk drive connected to the Apple II+ via a controller board. These are relatively easy to install. Some of the additional components when attached to the basic Apple II+ configuration made the entire system inoperative until either the problem was resolved or the component was removed. The following section highlights some of the problems experienced while assembling and integrating the Apple II+.

### 16.3.1 Insertion and Removal of Chips

Frequently installation of a component required the removal and insertion of integrated circuit chips. A special tool is available for removing chips; however we did not have the tool until half way through the installation process. A screw driver was used to pry up the chip, or it was loosened by hand and then removed. Several times staff members were stabbed by the pins on the chips or the pins were bent during the removal process. The pins had to be straightened before the chip could be reinstalled. There was considerable apprehension that if the pin on a chip was pushed too far it would break and a new chip would have to be purchased.

Problems also resulted from chips not being properly installed. In one instance, we thought we had damaged the computer and brought it back to the vendor's shop. The vendor found that a chip that appeared to be in place was not seated properly. The vendor uncovered this problem by removing chips, one at a time, replacing them, and then testing the machine.

The installation manuals warn that chips can be ruined by static electricity. It is best to discharge static from yourself and the machine before performing the installation. The technique offered for discharging static is to first turn off and unplug the microcomputer and then touch the power supply inside the Apple II+ case.

### 16.3.2 Trouble-Shooting

Sometimes after a component was installed, the component did not work properly when tested. Some of the installation manuals offered "trouble-shooting hints" but in most cases, these were not very helpful. The technique that proved most effective was to reread the instructions and retrace all the steps performed while checking that each item was installed properly.

### 16.3.3 Incompatible Components

The numeric keypad we originally purchased would not work with the keyboard enhancer since the Apple II+ unit could not be closed when the two components were installed. None of the vendors we spoke to before procuring the system indicated this was a potential problem. We expended a considerable amount of time trying to resolve this problem before finally returning to the vendor for help. The vendor replaced the numeric keypad with another that fit properly inside the Apple II+ enclosure.

### 16.3.4 Bad or Missing System Components

Several system components were faulty when received. The color monitor was DOA and had to be replaced. The green screen monitor required that internal adjustments be made at the vendor's shop. The vendor delivered the CORVUS hard disk and indicated it was set up to automatically boot the Apple II+. It failed to work properly. We had to reinstall the CORVUS disk and make it operational ourselves.

The shipment we received did not contain all the necessary cables. The original shipment contained only one cable for a monitor. Another cable was needed to run both monitors at the same time. A third cable was needed to connect the communications board to the modem, but the vendor did not consider himself obligated to supply this since he only supplied the communications interface and not the modem. This cable had to be specially wired for interfacing the modem and the communications board. Fortunately, the Technical Services Division of the U.S. Bureau of the Census was willing to custom wire this cable. We did not have the proper tools for this procedure.

### 16.3.5 Tools

When first assembling the Apple II+, we had five screwdrivers, two sets of pliers, and a wire cutter. During the installation process, we also obtained a set of tongs for removing chips, and borrowed a soldering gun for use in wiring a cable. It would also have been useful to have available a multimeter, or continuity tester, and needle-nosed pliers.

### 16.3.6 Installation Instructions

On the whole, the installation instructions for the microcomputer and its components were adequate. The instructions were understandable and usually provided step by step instructions. The problem with the installation manuals was the inadequate trouble-shooting information. If the component didn't work after being installed, the manuals provided little useful trouble-shooting information. Usually all the installation steps had to be carefully retraced, and if this didn't help, phone calls were made to the vendors.

The Videoterm 80 column display board comes with an installation and operation manual. This manual discribes how to install the display board but does not describe how to install the soft video switch. The installation instructions for the switch were found on a separate sheet of paper in the box, but these instructions did not provide a picture of the switch which would have been useful.

The CORVUS hard disk was probably the hardest component to install since a combination of hardware and software had to be installed. The CORVUS manual describes installation steps and software in one section and then repeats them in depth in another. The instructions are different for installing single user systems and networked systems. They are also different for users that have the Mirror backup, and users that want to create a Pascal-only, BASIC-only, or Pascal-BASIC system. Although the authors instruct the user on what sections to read in order to install a specific implementation, it is still quite confusing.

### 16.3.7 Outcomes of Experience Assembling and Integrating Apple Hardware

The ISPC experience assembling and integrating the Apple II+ hardware and software indicates that even "off-the-shelf" systems can be difficult to assemble. The problems and delays experienced while assembling our system would have been greatly magnified if the same had occurred in a developing country. Consider, for example, a user in a developing country receiving the Apple system unassembled in boxes. The nearest vendor is hundreds or thousands of miles away. The user simply could not bring the system into the shop and have someone look at it. Either the vendor would have to travel to the user's site or the component would have to be shipped back to the vendor for repairs. The user might not be able to contact the vendor by telephone to obtain assistance when problems arise and might not be able to quickly obtain tools for assembling the system. It is possible the user could give up trying before the system was ever assembled.

The following list of guidelines may be useful when considering assembly and integration of a microcomputer system such as an Apple:

-- The system should be assembled and tested (burned-in) by someone experienced with that equipment before it is shipped to the end-user. If the system cannot be assembled and tested before it is shipped, then the system delivered should be simple with easy to assemble components. Add-ons requiring board modifications, soldering, or rewiring should be avoided. Sometimes alternative add-ons are available that perform the same function and are not as difficult to install.

   Upon delivery of the system to the end-user, the system should again be assembled and tested by someone experienced with the equipment.

-- The user should be provided with some tools to facilitate assembly and maintenance of the equipment.

-- The user should be trained in how to assemble, use, and maintain the equipment.

### 16.4 Evaluation of Apple Software

The discussion of Apple software will be presented by operating system under which it functions and by specific software package within operating system.

#### 16.4.1 DOS 3.3

DOS 3.3 is included at no extra charge when an Apple disk drive and controller card (Model A2M0044) are purchased. The DOS 3.3 System Master diskette comes with useful utility programs and some games. BASIC is exceptionally easy for an experienced programmer to learn. The operating system commands are easy to understand and easy to use. Since BASIC is an interpreter, the user does not have to run a compilation step. Debugging can be done quickly since the programmer can easily check the values of variables after a program terminates or aborts, make modifications to the BASIC program, and immediately rerun.

##### 16.4.1.1 DOS 3.3 Documentation

Our system came with three manuals for BASIC, the Applesoft BASIC Programming Reference Manual, The Applesoft Tutorial and The DOS Manual. All three manuals are written for the inexperienced programmer with the text printed in black and highlighted information in green. Special symbols are used to catch the reader's attention and warn of possible dangers. The manuals are easy to read and, except for the BASIC Programming Reference Manual, contain numerous examples. The Applesoft Tutorial provides a novice user with a walk-through of Applesoft BASIC. The three manuals were adequate for our needs. The answers to most questions could be found in these manuals.

##### 16.4.1.2 Tasks Selected for Processing

The best way to determine the strengths and weaknesses of a computer system is to test the system under real work conditions. The following tasks were outlined for testing the Apple II+ running under DOS:

-- Acquire a statistical package and perform data entry, tabulations, and statistical analysis using that package. We obtained the statistical package ISIS, developed by Information Systems International.

-- Convert a BASIC program running on a different computer system to run under Apple II+ DOS. This would give some insight into the portability of BASIC programs.

-- Transfer files to and from Apple II+ DOS to both another Apple operating system and an IBM mainframe.

16.4.1.3 Statistical Processing using ISIS

ISIS, which stands for Interactive Statistical Inquiry System, is a user-friendly, menu-driven system designed to provide the user with a facility to enter data, edit data, create new variables from existing variables, generate reports, and perform statistical analysis on the data. ISIS does not provide for any editing of data at the time of data entry other than numeric and width-of-field tests. We decided to modify ISIS to also perform range editing (valid value edit) during data entry. This required modifying the BASIC programs in the ISIS system.

The Applesoft BASIC Programming Reference Manual in Appendix D offers space saving hints. These suggestions include "Use multiple statements per line," "Delete all REM statements," and "Re-use the same variables."(2) These suggestions make programs fit into a smaller memory space, but also make programs extremely difficult to read and understand. The authors of ISIS implemented the system using these techniques. Our original attempts at deciphering the code were futile. Another Apple user informed us of an article in a magazine called The Apple Orchard that listed the source code for a program that formats listings of Applesoft programs for improved readability.(3) We entered this program from the article onto our system and were able to list the ISIS programs in a much more readable format. This enabled us to identify the portions of code that needed to be modified.

Another problem arose when attempting to modify the programs. The text editing capabilites of the Apple system are extremely limited. The Apple editor cannot delete text or insert within a line of code. It can only overwrite or copy code on one line at a time. Global changes cannot be done. Renumbering of lines can only be done by using a separate utility. Unless the user invokes special commands for setting the text window, extra spaces are copied into source lines when lines exceeding the length of the screen are edited. Modifying the programs under these conditions was a slow and difficult process. The addition of range editing in ISIS was completed in 2-person weeks. The dificiencies of the Apple text editor are serious and slowed down our software efforts; however there are several BASIC program editors that are available at reasonable prices that replace Apple's limited editor.(4)

After adding the range editing capability to ISIS, we were ready to begin the data entry process. For input to ISIS, we used completed questionnaires obtained from the July 1982, Montour County, Pennsylvania, Agricultural Demonstration Survey. This survey was undertaken by participants of the ISPC Training Program.(5) The data collection effort was small; fewer than 125 farms were surveyed. There were 49 fields on the questionnaire and most questionnaires had fewer than 15 completed entries.

The data entry effort was not set up as a speed test for data entry on microcomputers, but rather as a means of gaining insight into the benefits and disadvantages of data entry on microcomputers. Undoubtedly, data entry under the Apple II was slower than under most traditional data entry techniques, but it was also more accurate since editing was being performed as data were entered.

Data entry of the questionniares went quite well. The data entry clerk entered approximately 25 questionnaires per hour utilizing the numeric keypad attached to the Apple. Since ISIS uses screen-formatted data entry, the clerk was able to visually verify and correct the data as they were entered. The clerk indicated that the ISIS data entry facility was easy to use, but that ISIS' use of questions requiring yes/no responses during data entry requires the user to move from the numeric keypad to the Apple keyboard to give the response and then return to the numeric keypad.

After the data entry process was completed, tabulations were run on the data using ISIS. The data were then transferred from the ISIS data base on the Apple to an IBM 3081 mainframe at the National Institutes of Health (NIH) where tables were produced from the data using CENTS 4, a tabulation system developed by ISPC. ISIS generates statistical frequencies and crosstabulations that look very similar to those generated by SPSS, a popular mainframe statistical package. Unlike SPSS, ISIS does not have a value label capability. The value label capability allows SPSS to place row and column labels on its crosstabulations. ISIS can only indicate the actual values being crosstabulated as its row and column headings. We selected four different tables to be created. These four tables were:

Table 1: Acreage for Selected Crops, 1981 and 1982. This was a simple sum of several variables (for example, acres of corn, acres of oats, acres of hay, etc.). The table was presented as years (columns) by Acreage of Crops (rows).

Table 2: Types of Farming Practices Relating to Corn Production by Age of Farmer. This was a crosstabulation with one dependent variable, Age of Farmer; and three independent variables, Using Chemical Fertilizers, Using Chemicals for Weed or Grass Control, and Using Advice of County Extension Agent.

Table 3: Types of Farming Practices Relating to Corn Production by Size of Farm. This was a crosstabulation with one dependent variable, Farm Size; and the same three independent variables described above.

Table 4: Preferences of Farm Operators for Policies to Increase Corn Production by Age of Farm Operator. This is a crosstabulation of two variables, Age of Farmer, and Which Government Program Influenced the Farmer Most.

Only Table 4 could effectively be created by ISIS as one tabulation. ISIS can only perform crosstabulation of two variables, and must create a separate crosstabulation for each independent variable supplied. Tables 2 and 3 each had to be created as three separate crosstabulations. The first table, Acreage for Selected Crops, 1981 and 1982, since it was not a crosstabulation, was recreated using the ISIS frequency routine. For each totaled value in the table, a separate frequency distribution was run.

In the tables created by ISIS, the percentages were not calculated in the way desired. Since ISIS offers no easy means of universe selection, it was unable to select fields based on a specific criterion. This resulted in irrelevant information being tabulated which distorted the percentages. Other values calculated by ISIS matched those in the CENTS 4 table printouts.

16.4.1.4 Conclusions on the ISIS Experience

Two tasks were identified to be performed as part of the project using ISIS. These tasks were:

-- Modify a software package to meet our needs.

-- Enter data from survey questionnaires; tabulate, report, and perform statistical analysis on that data.

The conclusions reached are based only on this one application of ISIS.

16.4.1.5 Modifying a Software Package to Meet Needs

ISIS was implemented in Apple BASIC, and, due to memory size limitations was written in a very compact style resulting in the source code not being very readable. The process of modifying ISIS to insert range checking was made more difficult by the limited text editing capabilities of Apple BASIC. Additional software should have been purchased to aid in text editing.

It is probably not advisable to assume that a package when purchased can be modified to meet a specific need even when source code is available. In this case, ISIS was difficult to decipher and modify. In some instances, vendors protect their programs by making them impossible to copy or do not supply the source code with the software package.

16.4.1.6 Processing of Surveys Using a Statistical Package

Although ISIS is limited in its printed table formatting, we felt that the use of the package was quite positive. Data entry was relatively fast and easy and the range editing enhancement helped detect errors during data entry. The tabulating portion of the system was easy to use, and the results were accurate. The time required to produce the four tables, once they were already

designed, was about 4 hours, compared to the 8 hours required to produce the CENTS 4 tables.

There is a definite tradeoff between using CENTS 4 and ISIS. ISIS is much easier and faster to learn and use. CENTS 4 allows universe selection (selection of a subset based on a criterion) and provides a much more elegant report that can be customized to meet the user's needs. The results of both packages are accurate. ISIS however allows a maximum of only 200 cases. Since CENTS 4 operates sequentially in a batch mode on data, there is no limit to the number of cases. If ISIS is to process more than 200 cases, a separate file must be set up for each block of 200 cases. Once data are entered into the ISIS data base, there is no easy way to perform consistency checks or other editing checks. When changes are made to the variables using ISIS, there is no way to obtain a printed log of the changes.

The statistical routines in ISIS are not always useful for statistical analysis of survey data. The algorithms in the statistical routines are designed with the assumption that each element has an equal chance of being selected in a sample. This is usually not the case in practical survey situations. Some of the transformation (variable manipulation) capabilities in ISIS can be used to help derive estimates in statistics required for a normal survey setting; however, in many cases it may be easier to write a custom program than to attempt to use ISIS to perform the calculations needed. The statistical analysis capabilities of ISIS may be better suited for researching data entered to gain insights into the survey. It should be noted that the weaknesses found in the ISIS statistical analysis routines are also true of many statistical packages found on mainframes.

16.4.1.7 <u>BASIC Program Conversion</u>

Portability, the ease or difficulty with which software can be transferred from one computer to another, is a major concern for ISPC. In the past, software developed by ISPC has been written in standardized languages such as ANS COBOL and FORTRAN using the lowest levels of the standard for those languages. With the advent of the microcomputer, it is now necessary to examine the portability of the microcomputer programming languages. Since BASIC is probably the most popular microcomputer language, we decided to test the portability of a BASIC program. Statistical Research Division (SRD) of the U.S. Census Bureau developed a pie chart program named QUICKPIE that was running on a Tektronix 4050 series system. SRD had a method for transferring data from their Tektronix 4052 to the UNIVAC 1100/83 at the U.S. Census Bureau. Using PTERM, the Pascal Operating System communications package purchased, we were able to download the QUICKPIE program from the UNIVAC 1100/83 to the Apple computer. (PTERM will be discussed later along with the Pascal Operating System.) After experiencing the difficulties described above in modifying the BASIC progams of the ISIS package, we decided to transfer the QUICKPIE program to the IBM 3081 at NIH and use the text editing capabilities of NIH WYLBUR. After the major modifications to QUICKPIE were complete,

the program was then downloaded to the Apple where testing and debugging were done.

The differences between Tektronix BASIC and Apple BASIC were significant. This is probably true of most BASIC's since although there is a proposed ANS BASIC standard, there is currently no recognized standard for the language. Some of the differences found included:

-- Tektronix BASIC allows for the use of function keys. Apple BASIC does not.

-- Tektronix BASIC allows trigonometric functions to operate in either degrees or radians. Apple only allows operation in radians.

-- The functions for manipulating strings in Tektronix and Apple BASIC were completely different. Tektronix does not allow for subscripted string variables.

-- The graphics commands for the two systems were completely different. There is no accepted graphics standard for BASIC. The WINDOW and VIEWPOINT commands in Tektronix allowed scaling to be changed. Apple BASIC has no comparable command. Tektronix uses the commands MOVE and DRAW where Apple uses HPLOT. Apple BASIC cannot easily overlay text onto the graphics image as can Tektronix.

-- The syntax of the GO TO DEPENDING ON differed between the two machines.

-- Tektronix has the PRINT USING statement which allows for formatted I/O. Tektronix had several I/O commands that were different than those in Apple BASIC.

Along with these differences, a memory space problem was encountered on the Apple. When high-resolution graphics were invoked, part of the BASIC program was overwritten by the high-resolution graphics screen buffers. The modifications required to make QUICKPIE operational on the Apple would have taken much longer than was allowed for this task. Although very enlightening, the QUICKPIE task was discontinued before conversion was complete.

16.4.1.8 <u>Transfer of Files Between Apple Operating Systems and Other Computers</u>

As mentioned earlier, three operating systems were purchased for the Apple. These operating systems were DOS 3.3, Apple Pascal, and CP/M. Unfortunately, these three Apple operating systems format disk files differently, and none can read the diskettes formatted by the others. This is not a hardware problem; rather, it is related to the design and location of each operating system's volume directory blocks and files. Utilities exist that provide a means of exchanging files between DOS and Pascal. The source code

to two of these utility programs, GETPAS and GETDOS, was published in BYTE Magazine. GETPAS converts Pascal files to DOS. GETDOS converts DOS files to Pascal format. We entered these utilities onto our system from listings of the programs.(6) The CP/M Operating System diskette comes with a utility named APDOS that provides a means of transferring files. The GETDOS and GETPAS utilities worked quite well, the only problems occurring when files were large (over 400 lines). When the input file was large, GETPAS, the Pascal to BASIC conversion program, would error terminate with the message "ILLEGAL QUANTITY ERROR." On large files, GETDOS, the BASIC to Pascal conversion program, would terminate with the message "NOT A TEXT FILE." Both GETDOS and GETPAS are user-friendly and prompt the user for the required inputs. APDOS converts files from DOS to CP/M format. It is not user-friendly, requiring documentation to be used correctly. The program generates a file containing a carriage return but no linefeed at the end of each line. This is suitable when the file being transferred is a BASIC program to be run under MBASIC (Microsoft BASIC), but other files must be reformatted for use in different applications. The three utilities, GETDOS, GETPAS, and APDOS, provide an adequate, but not great, means of transferring files among operating systems.

As part of the ISIS statistical package evaluation, tables were created using both ISIS and CENTS 4. Since CENTS 4 runs on mainframes and minicomputers, data stored in the ISIS data base was transferred to the IBM 3081 at NIH. Since GETDOS can only read sequential text files, and the ISIS data base stores data in random access format with multiple fields in multiple files, the data had to be reformatted using a custom-written program. This program read the ISIS data base and generated a sequential text file. The file was then reformatted (using GETDOS) into a Pascal text file. With the file in Pascal format, PTERM was used to transmit the data to the IBM 3081. This was done by executing PTERM, dialing NIH's WYLBUR (an online interactive communications system), and then invoking PTERM's terminal mode processing. Once a successful "logon" to WYLBUR has been completed, WYLBUR was set to input mode and PTERM was set to transmit the text file. When transmission of the file was complete, PTERM was again set to terminal mode, the WYLBUR input mode was terminated, and the file was saved.

For some reason, every seventh record transmitted to NIH using PTERM was missing one character. No matter what transmission speed and delay characters were used, a random character would be missing from each seventh record. This may have been related with block reads performed by PTERM on the CORVUS disk. We were not able to resolve this problem and finally had to resort to editing the transferred file. Noise over communication lines and handshaking incompatibilities can cause data to be incorrectly transferred. According to many experienced microcomputer users we discussed this problem with, losing data is a common problem when using communications packages on microcomputers.

### 16.4.2 Pascal 1.1

Of the Apple Operating systems evaluated, Pascal 1.1 is the most elegant and powerful. It is a user-friendly, menu-driven operating system that prompts the user for inputs as needed. The system comes complete with a file transfer utility, a relatively powerful text editor, a Pascal compiler, an Assembler, a linker, and a number of utilities, including a library, facility for linking separately compiled routines into a library and a calculator utility that allows the computer to be used as a simple calculator. In addition, the Pascal operating system provides a means of creating a text file containing a series of commands. Both CP/M and DOS 3.3 also allow the creation of command files, but Pascal allows the creation of the command file as the commands are being executed. In the acknowledgements section of the Apple Pascal Operating System Reference Manual it states, "The Apple Pascal system incorporates UCSD Pascal and Apple extensions for graphics and other functions."(7) Although Apple refers to the operating system as the Apple Pascal system, it should be understood that other languages such as FORTRAN-77 and an assembler run under this operating system.

Our Apple Pascal Operating system with manuals cost $225. Since the operating system requires a full 64KB complement of memory, we also had to purchase a RAMCARD which is packaged with other items.

The Pascal compiler is actually a pseudo-compiler. The compiler generates an intermediate code called p-code which is interpreted at execution time. Since Pascal compiles, every time a correction is made to a program, the program must be recompiled before testing. This makes testing and debugging much slower in Pascal than in DOS BASIC. DOS BASIC is an interpreter and requires no separate compilation step. When a Pascal program error terminates, there is no way to examine the value of variables at the time of error termination. DOS BASIC allows the user to easily check the value of variables after execution. As is true of DOS BASIC, Pascal indicates the line at which the error termination occurred, and in most instances this greatly aids in the debugging process.

#### 16.4.2.1 Apple Pascal Documentation

As mentioned earlier, Apple Pascal is quite powerful. In order to gain a good grasp of the capabilites of the operating system and compiler, the user needs to regularly refer to manuals while learning the system. This is particularly true when using the Pascal text editor. The editor is powerful, but the menus supplied to the user are very brief. We received three manuals with our system, Apple Pascal Operating System Reference Manual, Apple Pascal Language Reference Manual, and Apple Pascal: A Hands-on Approach. It becomes apparent quickly that the Apple Pascal manuals are not for the novice programmer. In the Apple Pascal Operating System Reference Manual, it states "The Apple Pascal Operating System Reference Manual and the Language Reference Manual...are most definitely not intended for beginners at using computers and Pascal."(8) This statement is correct. The manuals

are difficult to read and comprehend. Unlike DOS, there is no Pascal tutorial manual. In the Apple Pascal Language Reference Manual it states, "This is a reference manual designed to give you the facts without very much emphasis on teaching you Pascal."(9) The Apple Pascal: A Hands-on Approach is the closest to a tutorial manual, guiding the reader through a sequence of "revealing" experiences in using Pascal.(10) It should be noted that there are good tutorial manuals available commercially.

16.4.2.2 Tasks Selected for Processing

The following tasks were outlined for testing the Apple System under Pascal:

-- Development of a user-friendly color graphics software package.

-- Development of an on-line interactive data entry system to capture and edit data from foreign trade import forms at a customs site. This system would interface with a graphics system.

-- Evaluation of a communications package.

16.4.2.3 Development of the Color Graphics Software Package

Two of the major enticements for using microcomputers are its ease of use (user-friendliness) and its graphics capabilities. The purpose of our developing a graphics package was to:

-- Gain insight into the complexities of developing user-friendly software;

-- Gain insight into the complexities of using the graphics capabilities of microcomputers;

-- Improve our knowledge of Pascal as a programming language; and

-- Determine the usefulness of existing graphics capabilities for NSO reporting needs.

It was decided that a user-friendly bar-charting program would be developed. The staff member selected to develop this graphics package, although an experienced senior programmer, had no previous experience using Pascal. He spent some time sitting at the Apple while reading both the Apple Pascal Language Reference Manual and the Apple Pascal Operating System Reference Manual. While reading the manuals, he would occasionally try some of the examples on the Apple. After developing a feel for the Apple Pascal, he then began coding the program. Coding took approximately one day. Entering the program on the Apple and debugging took another 1-1/2 days. Modifications to the program to incorporate improvements suggested by others took another two days.

The barcharting program, called BARCHART, consists of 280 lines of Pascal code. Approximately one-half of that code is the user interface, the remaining code being used to draw the barchart. The programmer indicated that the user-friendly interface was not as "friendly" as he hoped, and the programmer could have expended considerably more time on improving the user interface code. The barchart program generates a labeled barchart with increasing values along the Y-axis and labeled events along the X-axis. The bars appear, alternating in five different colors. The barchart program user is prompted for the X- and Y-axis titles, the optional Y-axis minimum and maximum values, the increment for tick marks along the Y-axis, and the bar values and labels. After the barchart is created, the user is given the options of printing the barchart on the line printer and saving the user parameters that created this chart. This chart can be recreated easily by indicating to the program that it is to accept the parameters from a file rather than from the keyboard.

16.4.2.4 Conclusions on Development of the Graphics Software Package

In the opinion of the programmer that developed BARCHART, the Pascal operating system and editor are much better suited for software development than the comparable facilities on DOS. The Pascal editor offers much greater editing capabilities than those offered with standard DOS. The Pascal language is much more structured than BASIC, offering such language constructs as CASE statements, IF-THEN-ELSE, REPEAT-UNTIL, WHILE-DO, and BEGIN-END. Both procedures and functions can be written by the user. The program written is more readable since long variable names, comments, and cosmetic spacing have little or no effect on the size of the generated program. In BASIC, the user is encouraged to write the program in a very compact style in order to save memory space. Debugging of Pascal programs takes longer since every time a problem is corrected, the program must be recompiled before it can be rerun. However, the structured format and readability of the Pascal programs should greatly simplify coding and debugging, while eliminating errors before they are introduced.

Graphics applications, in particular color graphics, are quite simple to develop using Apple Pascal. Apple Pascal uses "turtlegraphics," a graphics technique based on the system designed by Seymour Papert of MIT to make graphics easy for children who might have difficulty understanding Cartesian coordinates.(11) The idea is based on the concept of a "turtle" that can walk and turn a specified angle while dragging a pen. Apple Pascal also offers Cartesian graphics which has a MOVETO (X,Y) command. Pen color can be selected using the PENCOLOR command. Creating color graphics using Apple Pascal is relatively easy.

Developing a user-friendly interface for BARCHART was more difficult than expected. As mentioned earlier, one-half of the code written was for the user interface and the programmer indicated that the interface could have even been more user-friendly. BARCHART offers no numeric, range, or consistency

checks. The claim is made that microcomputers are "user-friendly." Microcomputers in and of themselves are not user-friendly. Software allows microcomputers to become user-friendly if the software is written properly. A significant portion of the time required for software development on microcomputers will need to be expended on the development of user-friendly interfaces.

16.4.2.5 Development of a Foreign Trade Import System

The major emphasis of the Microcomputer Feasibility Study was to research microcomputers as applied to the tasks normally undertaken in National Statistical Offices (NSO's) of developing countries. One of the important functions of an NSO is the generation of foreign trade statistics. Based upon discussions with individuals familiar with foreign trade data processing in developing countries and with staff members of Foreign Trade Division (FTD) of the U.S. Bureau of the Census, we designed a prototype system for processing foreign trade import forms. This prototype system was to demonstrate a possible application of microcomputers in an NSO.

When imports are received from another country, an import form specifying the characteristics of the shipment is completed. This form contains general information about the shipment received such as:

-- Document ID
-- Entry port name and code
-- Entry date
-- Transporation type
-- Country of origin name and code

For each commodity in the shipment, the following information is also typically provided:

-- Commodity name and code
-- Net quantity
-- Shipping weight (lbs. or other unit of measurement)
-- Value
-- Duty

The purpose of the prototype system was to allow a receiving clerk or a data entry technician to enter this information into the computer under edit control, and then provide a means of generating graphic summarizations of the information entered. The system was to be designed for users not familiar with microcomputers and was to be user-friendly, prompting the user with questions as processing proceeds. If any problems, such as invalid or inconsistent values, were detected by the system, the clerk was to be informed of the problem and then provided an easy means of correcting the problem. After the forms were entered, the system was to provide a means of generating graphic representations of information entered. Information such as shipments by area of the world, shipments by transportation type, and commodities by commodity grouping, were to be represented by barcharts and/or piecharts.

The system design consisted of the design of the import form, the menu screens the user would see, and a list of the edits required for each field entered. Foreign Trade Division was able to supply us with a tape containing three files identifying the U.S. Census Bureau's valid commodity codes and names, country codes and names, and U.S. port codes and names. These three files were copied onto disk on the IBM 3081 mainframe at NIH, transmitted using PTERM, and then stored on disk on the Apple. A discussion of PTERM is given later in this chapter.

The same senior programmer that wrote the barcharting program was assigned the task of developing the prototype foreign trade system. Realizing the deficiencies in the user-friendly interface developed for the barcharting program, his first task was to design a set of Pascal routines that could be used for providing an interface with the user. These routines performed such tasks as clearing the screen, printing text at certain positions on the screen, accepting data of a specified length, checking the data to see if it was numeric, and prompting the user for yes/no responses. These routines were stored as a unit in a Pascal system library for use by accessing programs.

The next step was the development of the import form data entry program. The import form data entry program was much more sophisticated than the barchart program. In order to check the validity of the commodity, port, and country codes, the program was designed to perform a binary search of the commodity, port, and country code tables. A program was written to reformat these tables from sequential text file format to a random access format. Additional inputs, such as a file containing user-ids and other files containing program parameters and text, had to be read. A user-friendly interface had to be written to call the routines already stored in the Pascal system library.

Development of the foreign trade import form program, called FOREIGN, made us more aware of the 64KB memory limitations of the Apple. It also made us more aware of some limitations of the Apple Pascal operating system. At one point, the Pascal compiler kept error terminating with the message "STACK OVERFLOW." When we modified FOREIGN, the Pascal compiler would terminate at a different location during compilation but with the same "STACK OVERFLOW" message. While discussing this problem with another Apple Pascal user, he suggested that we use an option in the Pascal compiler that puts the compiler in "swapping mode." We tried this and it solved our problem.

The next major problem occurred when the FOREIGN program again started error terminating, with the same "STACK OVERFLOW" message. This message indicates that there is not enough available space in memory to execute the required task. We had reached the limits of the Apple's memory. Although the Apple has 64KB of memory, the memory available for a p-code file is much less, at somewhere between 37KB and 40KB of memory. Since the 40-column screen requires more memory than the 80-column screen on our system, we had slightly more memory available than on a 40-column system.

It should be noted that once we had reached the memory limits of the Apple II+, and there was still a considerable portion of the FOREIGN program to be written, that the remainder of the system development required the use of memory saving techniques. Existing portions of the program were modified to require less memory, arrays were decreased in size, recursion routines were avoided, files were closed as soon as possible to free up the file buffers, and the number of concurrently active files was minimized by opening and closing files sequentially whenever possible. In some cases, a file was opened and closed for each record read to free the buffer space. By segmenting the Pascal procedures, we were able to save more space. Segmenting procedures or functions results in code not being loaded into memory until it is needed. By carefully declaring variables and files at the lowest level needed, and avoiding the definition of global variables whenever possible, more space was made available. This attention to memory-saving techniques makes program development on a microcomputer, as opposed to a mini- or mainframe computer, more difficult. In some instances, program execution efficiency is sacrificed to save memory space.

Another limitation encountered during development of the FOREIGN program was the size of the text files that could be loaded into the text editor. FOREIGN became too large to edit using the text editor. By setting an option in the operating system, more memory was made available for the editor. More memory was freed up by eliminating cosmetic spacing. Some routines were transferred into the Pascal system library and were removed from the FOREIGN program. Even with the removal of cosmetic spacing, the program was still quite readable. It was later discovered that by using the "include file" compiler option we could have separated the source program into two or more text files. This would have solved our space problem when using the text editor. Unfortunately, we did not discover this option until after the problem was solved.

The most difficult part of using the Pascal programming language is understanding the TYPE declaration. The TYPE declaration allows the user to define new types of variables. Examples of standard Pascal variable types are INTEGER, REAL, BOOLEAN, and CHAR. The TYPE command allows the user to define types of variables that restrict the range of valid values. As an example, a type called MONTH_OF_YEAR could be restricted to the values 1 to 12. The TYPE command can also be used to define a record type as a combination of other variable types. This allows record field definitions within the program. For a new Pascal programmer, learning the use of the TYPE statement for record definition is difficult.

Once the FOREIGN program was operational, research began on developing an interface program between the output created by FOREIGN and the Apple II Business Graphics software package. Apple II Business Graphics is a user-friendly program for developing barcharts, piecharts, and line charts. The plan was to generate a file that could be read as input to the package and automatically generate charts.

There were some problems getting the Apple II Business Graphics package operational on our system. First, the Apple II+ system had to be booted using the Apple II Business Graphics diskette. It had to be booted from slot 6, drive 1. This meant the CORVUS controller had to be removed from slot 6 and replaced with the floppy disk controller that was in slot 4 every time the graphics package was to be run. Second, the graphics system diskette could not be copied using standard copy routines. By using a special disk file copy utility, we were able to successfully copy the diskette while eliminating the block causing the copy problem. Using the new diskette, we were then able to copy the system library to the CORVUS. Once this was done, we were able to run the graphics program from the diskette without having to move the disk drive controller boards.

With Apple II Business Graphics running on the Apple, we were ready to start development of the interface between FOREIGN and the graphics package. The easiest method of creating an input to the graphics package was to create an Apple Pascal EXEC file which could be executed to draw the graphs. An EXEC file, when executed, acts as though the user had typed in the commands contained in the EXEC file from the keyboard. The interface program was to ask the user what charts were desired, tabulate the necessary information from the import forms file created by FOREIGN, and create an EXEC file for input to Apple II Business Graphics.

The interface program, called FRGNTAB, was developed and operational in two days. With this accomplished, the prototype foreign trade system was complete. The system consisted of three programs, FOREIGN which provided for data entry and editing of the import forms, FRGNTAB, which provided for selection of the information to be represented graphically, and Apple II Business Graphics which used the EXEC file created by FRGNTAB to create charts. The time required to complete the entire system was 3 weeks.

16.4.2.6 <u>Conclusions on the Foreign Trade Application</u>

Developing the foreign trade system was a very informative project. It showed the strengths and weaknesses of both the Apple II+ and the Apple Pascal operating system. The conclusions reached were:

-- The Apple Pascal operating system is much more user-friendly and powerful than Apple DOS.

-- The editor is much more powerful than that available with DOS and even in comparison with some editors that can be purchased for DOS.

-- Pascal is a good language for the development of complex software. It is quite readable and easy to debug due to its highly structured design. Software development and debugging of simple or small programs may be faster and easier in BASIC.

-- The limitation of 64KB of memory on the Apple is a significant concern. This limitation not only affects the generated programs, but also has an impact on the text editor and the Pascal compiler by limiting the size of items that can be processed.

-- Certain software packages will not run on some computer configurations although it might appear that they should. It is probably a good idea to be sure a package will run on a specific configuration before the package is purchased. One should try to identify a user who has successfully integrated a specific software package on a specific microcomputer configuration. We were lucky in that we were able to circumvent this problem.

-- Microcomputers are only user-friendly if their software is user-friendly. Just because a computer program runs on a microcomputer does not mean the program is user-friendly. Elaborate user interfaces must be written to make software truly user-friendly.

16.4.2.7 <u>Evaluation of the PTERM Communications Package</u>

PTERM is the package used to achieve communications between the Apple and other computer systems. It is a user-friendly, menu-driven system that allows the user to interact with the communications software on another computer system, and also allows for the sending and receiving of files.

PTERM, as delivered by the vendor, transmits data at 8 bits, even parity with 2 stop-bits. The IBM 3081 at NIH expects 7 bits, even parity with 1 stop-bit. The PTERM manual gives clear instructions on how the program can be modified to change these settings. The modification was done quite easily.

Using PTERM, we were able to communicate with the NIH IBM mainframe. On several occassions we transmitted data to NIH or receved data from NIH. PTERM was used during the ISIS project to transmit a data file to NIH. During the Foreign trade system project, files were downloaded from NIH onto the Apple. Using PTERM, the QUICKPIE program (developed on a Tektronix machine) was transferred to NIH to be modified, and then was downloaded to the Apple.

PTERM was very easy to use, however, at 1200 baud it always seemed to lose something during transmission. During the transmission of ISIS to NIH, we lost one character every seven records. During the downloading of code tables for the foreign trade project, an occasional character would disappear. Missing characters also were a problem during the work on the QUICKPIE program. Some of these problems could be blamed on noise over communications lines; however, this could not account for all lost characters. Although PTERM rarely dropped characters, this may not be acceptable for some users.

16.4.2.8 Conclusions on Apple Pascal

Apple Pascal is a powerful operating system. It is also a complicated system to use and the manuals provided with it are not designed for novice programmers. The text editor is very powerful, providing many editing features found on mainframe computers. The utilities available provide many nice features including a flexible file transfer utility, and a library utility for storing external routines in the system library.

Pascal appears to be a good language for the development of large complicated programs. Its highly-structured language allows it to be more modular and more readable than BASIC. Even with the efforts made to make the Pascal program file more compact, the program was still quite readable. As mentioned under the discussion of Apple DOS, BASIC can become incomprehensible when the program is made more compact. The GOTO statement can be totally avoided using Pascal since IF-THEN-ELSE, WHILE-DO, and procedure calls can replace the same logic. The modular and more structured code of Pascal allows the development of complex programs with more easily followed logic; this means less time spent coding and debugging.

16.4.3 CP/M 2.2

CP/M 2.2 is an operating system designed to run on systems using an Intel 8080 compatible CPU. Since the Apple II+ uses the MOS Technology 6502 CPU, an additional board containing an Intel 8080 compatible Zilog Z80 CPU was purchased. CP/M is one of the most popular operating systems for 8-bit microcomputers and a wide variety of software runs under the operating system.

Apple CP/M comes with MBASIC and GBASIC. GBASIC is a version of Microsoft BASIC that contains high-resolution graphics.(12) MBASIC is also Microsoft BASIC without a high-resolution graphics capability but with more available memory. GBASIC uses the HGR, HCOLOR, and HPLOT commands which are the high-resolution graphics commands found in DOS 3.3 BASIC.

The CP/M operating system is not very user-friendly. There are no menus or submenus supplied by the operating system. The editor ED that comes with the system is difficult to use. Its command notations are not very meaningful. Other editors for CP/M can be purchased that are much more powerful and easy to use. MBASIC and GBASIC come with their own editing capability which is better than DOS BASIC, but not as good as the CP/M editor. CP/M in itself is not a very powerful operating system, however there is a great deal of public domain software that when added to the operating system makes it more usable. The discussion on the use of ISPC's CompuPro System will cover CP/M in more detail.

16.4.4 Conclusions on the ISPC Experience Using the Apple II+

There were two major parts in ISPC's experience using the Apple II+. The first part was the assembly and integration of the

hardware and software. The second part was the evaluation and use of the three operating systems purchased, DOS 3.3, Apple Pascal, and CP/M 2.2, and evaluation of software running on those systems.

16.4.4.1 Assembly and Integration of Hardware and Software

The Apple II+ is one of the more established microcomputer systems around. Almost every component purchased for the machine has been around for years and is considered reliable. Yet when assembling these components, we had one problem after another. Most of the problems were not our fault. Faulty components were our major problem.

The solution to avoiding the problems we encountered is to have someone experienced with the hardware and software assemble and burn-in the equipment. If the system is to be shipped overseas, the system should be assembled and burned-in for 72 hours before being shipped overseas, and then assembled and tested again after being delivered. This should be done by a person experienced with that equipment. Backup components and even an entire backup computer may be a good idea.

If it is not possible to have the system assembled by a person experienced with that equipment, then the system shipped should be very simple to assemble. In any case, the end-user should be supplied with adequate tools and training for assembling and trouble-shooting the hardware.

16.4.4.2 Evaluation and Use of Apple DOS 3.3, Pascal, and CP/M

Of the three operating systems evaluated, Apple DOS 3.3, Pascal, and CP/M, Apple Pascal was the most powerful operating system and Pascal was a better language for sophisticated software development than either DOS BASIC (Applesoft BASIC) or MBASIC (Microsoft BASIC). Pascal allows the user to develop highly-structured code, dividing complex programs into logical blocks or modules. This enables the programmer to read and debug code more easily. Apple Pascal, which is based on UCSD Pascal, is also more portable than the BASIC's evaluated. UCSD Pascal is a highly portable operating system which is running under a wide variety of systems. It has been implemented on the Z80, 8080/85/86/88, PDP-11/LSI-11, 6502, TI9900, 6809, 68000, and even for DEC's VAX-11 CPU's.(13)

For simple tasks, or "quick and dirty" applications, BASIC is a better language than Pascal. BASIC does not require the definition of any logical blocks of code and also does not require the predefining of most variables. Unlike Pascal, interpretive BASIC does not require a compile step, and the examination of BASIC variables is easy when an error termination occurs. Software development in BASIC will be faster when the software being developed is not very complex or large.

It should be noted that Pascal compilers that run under CP/M do exist. There is more software available for CP/M than for Apple Pascal. If both Pascal and BASIC compilers were available under

the same operating system, then BASIC could be used for the simpler applications and Pascal for the more sophisticated applications. This would be an ideal situation.

The 64KB limitation on the memory size for the Apple II+ is a serious constraint. In order to make software "fit" in memory, it is often necessary to sacrifice program efficiency or the readability of code. For many applications of microcomputers in an NSO, it may be necessary to use a microcomputer with a capability to directly address a significantly larger amount of memory.

# FOOTNOTES

1 Apple Computer Inc., Apple Pascal Operating System Reference Manual, 1980, Preface.

2 Apple Computer, Inc., Applesoft BASIC Programming Reference Manual, 1981, p. 118.

3 Robert C. Clardy, "Applesoft Program Listing Formatter," The Apple Orchard, Winter 1980, p. 21.

4 David Durkee, "Applesoft Makes a Level," Softalk, Vol. 3, No. 12 (December 1982), p. 68.

5 U.S. Department of Commerce, Bureau of the Census, Agricultural Demonstration Survey Reference Manual, (July 1982), p. 1.

6 John B. Matthews, MD, "Converting Apple DOS and Pascal Text Files," BYTE, Vol. 7, No. 4 (April 1982), p. 447.

7 Apple Computer Inc., Apple Pascal Operating System Reference Manual, Preface.

8 Ibid., p. 2.

9 Apple Computer, Inc., Apple Pascal Language Reference Manual, 1980, p. 2.

10 Arthur Leuhrmann and Herbert Peckham, Apple Pascal: A Hands-On Approach, (New York: McGraw-Hill Book Company),p. 2.

11 Apple Computer, Inc., Apple Pascal Language Reference Manual, p. 90.

12 Microsoft, Softcard, 1980, Vol. 2, p. 4-98.

13 Mark Overgaard, "Implementing the UCSD p-Systems," Mini-Micro Systems, Vol. 15, No. 9 (September 1982), p. 183.

# CHAPTER 17: THE ISPC COMPUPRO SYSTEM

## 17.1 Preparing for Procurement

### 17.1.1 Deciding What the Microcomputer Would Be Required to Do

The microcomputer procurement process began for us with a review of those processing tasks that we most often encounter in working with NSO's in developing countries. It was our intention to identify the most ambitious of those tasks that we believed could be accomplished on a microcomputer without a major modification of the methods we use in processing on a mainframe computer and to use the microcomputer to perform them. We realized that the completion of this work would require the use of existing software and data if it were to be accomplished within the allotted time and budget of this project. Once processing of the data was complete using traditional methods, we planned to move on to attempt a similar process using packaged software available for microcomputers and using some of the newer programming languages to work with the data.

Since we were, and are, at least partly persuaded by the literature and by well-informed individuals that microcomputers by their very design urge fresh approaches to data handling and processing, a word needs to be said about our choice of traditional processing methods as the starting point of our procurement decision for a microcomputer. First, we speculated that, at least at the start, a primary motive for selection of a microcomputer for processing in the NSO of a developing country would be the microcomputer's cost advantage when compared to a mainframe or minicomputer. Data processing managers would want to use existing staff skills, familiar methods, and even existing software if they could do so. We thought, also, that microcomputers available early in 1982 were capable of providing an environment in which traditional approaches to survey data processing utilizing custom programs written in COBOL and FORTRAN could be carried out. A successful, or even an unsuccessful, attempt to use programs developed on and for a mainframe computer would provide insights invaluable in deciding whether or not the microcomputer would be useful in situations where a minimum of retraining was possible or costly existing software had to be used.

With this in mind we sought to identify a survey of modest size for which programs and data were available for processing. A rural electrification survey conducted in Indonesia by staff at the Perusahaan Umum Listrik Negara (PLN) in 1980 was selected. The processing system for the survey, known as the 'Klaten' survey after the name of the primary village being studied, was developed by PLN programmers under the guidance of ISPC staff at ISPC offices in Marlow Heights, Maryland. Data were keyed to disk in Jakarta and transferred by magnetic tape to Marlow Heights for computer processing. Both data and programs for the survey were available to us at the computing center at the National Institutes of Health (NIH) in Bethesda, Maryland. Program development and processing of

the survey data were accomplished originally using the IBM facility at NIH between November 1980 and February 1981. On-line data storage requirements peaked at approximately 8.5MB in January 1981.

| | PROGRAM | SOURCE LANGUAGE | NUMBER OF LINES |
|---|---|---|---|
| 1. | Check-in program including a count of non-interviews and a correction of incorrect stratum assignments. | COBOL | 1130 |
| 2. | Valid-value edit program. | COBOL | 486 |
| 3. | Consistency edit program. | COBOL | 1189 |
| 4. | Record listing program. | COBOL | 355 |
| 5. | Record update program. | COBOL | 594 |
| 6. | Recode program. | COBOL | 403 |
| 7. | Variance calculation program. | FORTRAN | 408 |
| 8. | Table A | COBOL | 366 |
| 9. | Table B | COBOL | 398 |

FIGURE 1. Programs Comprising the Klaten Household Survey Data Processing System.

The Klaten sample consisted of 600 households. Each household record contained 100 variables after all recodes were complete. Figure 1 identifies the custom programs that made up the processing system as it was designed in 1980. In addition to the programs shown in Figure 1, the system relied upon an IBM sorting utility to order the household records and included CENTS programs to generate approximately 75 tables. Because CENTS was not yet available for microcomputers, these tabulation programs could not be used in this exercise, and it was planned that two representative tables would be coded in COBOL to be used in their place. We planned to merely download the programs and data using telephone communications to connect our microcomputer with the dial-up terminal facility at NIH.

The second task outlined for the microcomputer system was that of processing the Klaten data file using packaged software available in the marketplace. We hoped to be able to assess the relative ease and completeness of an alternative process and to determine whether the facilities provided by data base management software for microcomputers could be used in lieu of custom programs for all phases of data editing. In addition, we wished to examine the

suitability of tabulation and statistical packages for table production and data evaluation in a survey of modest size.

In addition to these two specific tasks, we wanted to examine the usefulness of the microcomputer for a number of office jobs such as word-processing and project management accounting as well as in handling the large files of information that were being collected for this study. We chose to consider a multi-user environment for this work not only to assess this capability of small systems but to squeeze as much function out to the system as possible in the limited time that we expected to be able to pursue this part of the study.

Having made a decision on how the microcomputer would be used, it was a straightforward task to draw up the following list of system requirements:

(1) Communications capability (including software support);
(2) Memory of at least 96KB to accommodate the largest of the COBOL programs to be run;
(3) A COBOL compiler;
(4) A FORTRAN compiler;
(5) A 132-character printer (dot-matrix quality was acceptable);
(6) On-line storage of at least 10MB;
(7) A multi-user operating system;
(8) Two 80-character x 24 line CRT terminals;
(9) Additional compilers (to include at least BASIC and Pascal);
(10) Data base management software;
(11) Statistical software;
(12) Tabulation software;
(13) Electronic spreadsheet software; and
(14) A sort/merge utility.

17.1.2 Further Procurement Criteria

Recognition that we intended to make a statement about the feasibility of using microcomputers for jobs commonly performed by NSO's made us particularly concerned to see that we had access to the best of current microcomputer technology. We wanted the results of our work to reflect experience with state-of-the-art equipment, and we hoped to guard against reaching a negative conclusion as a result of the inadequacies of the particular microcomputer chosen.

It was obvious very early in our attempts to identify those systems that might be representative of the state-of-the-art that there was considerable risk in attempting to move too far forward with respect to the development of the technology. For example, we judged the Motorola 68000 microprocessor chip to be the most powerful and technically most superior chip available in general purpose microcomputer systems at the start of 1982. We found, however, on repeated occasions that systems utilizing the M68000 chip advertised at that time were not operational (due to the incompleteness of system and support software) or, if operational,

were insufficiently reliable to see our work to completion. Both the TRS-80 Model 16 and WICAT's System 150 were of interest to us. In a visit to a Radio Shack store to examine the TRS-80 system, we found that no operating system capable of using the Motorola chip contained within the system was available. The WICAT System 150 was demonstrated twice for us. On the first occasion the operating system was operational, but neither we nor the vendor were able to compile a program successfully in Pascal, the only high-level language available on the machine at the demonstration. At a demonstration by a regional representative several weeks later, we successfully compiled a Pascal program but only after a WICAT technician present at the demonstration bypassed a halt in operation resulting from errors generated during a compilation with a series of undocumented commands.

Despite this unsettling warning, we believed it critical to select equipment that was technically superior and that incorporated as many as possible of the newest developments in microcomputer technology. In addition to being risky, this goal was in conflict with our desire to keep costs low and to select a system that would be a likely candidate for use in many developing countries. In the end, the goal of technical superiority was to completely supplant our concerns for cost or availability.

Our goal with respect to cost was merely to keep the cost well under typical minicomputer system costs. We were persuaded that even if the system should prove expensive by microcomputer standards at the time of its procurement, it would be unlikely to cost as much in two to three years. The cost of a chip drops dramatically after the market has been opened and development costs have been met. The cost of memory and peripheral storage has tended to decline steadily. The cost of software designed for the newer technology, too, while high when first introduced, drops as the number of potential users increases with wider adoption of the newer technology.

With respect to availability, we were less inclined to be bound by our concern that a system that we might select would not be ideal for use in a developing country due to the lack of vendor support or local representation. After we reviewed reports of the system usage abroad, we found that system usage was not limited to the more widely distributed models such as the Apple II and the TRS-80 but spanned the full spectrum of microcomputer systems. We learned that Cromemco's were being used in Burma without the benefit of local representation, and the Burmese were pleased with the cooperation of Cromemco in California. We learned that Ecuador had selected Alpha Micro equipment for use in census processing, in part because Alpha Micro is well represented in Ecuador. The implication of this seemed to us to be that developing countries would be better served by an assessment of the technology rather than an evaluation of systems commonly available overseas. While we realized that the peculiarities of any system selected could not be overlooked, we felt it imperative to see the best of microcomputer technology.

We found that we not only had to be careful in placing ourselves too far foward with respect to the development of the technology, but that we also had to be wary of claims made by vendors on the availability of software for their products. On several occasions "availability" turned out to be little more than the vendor's way of saying that he was examining the possibility of obtaining a license for the software and making the modifications necessary to make it available for his system. As an example, we were assured by one vendor that Ryan McFarland COBOL was available for his system. A check with Ryan McFarland revealed that Ryan McFarland had no formal agreement with the vendor at that time, although the company representative was aware that discussions with the vendor had been held. At times it was extremely difficult to determine with any confidence what software was available for a given system. Microsoft, one of the major software houses, informed us that all of their 16-bit software was being developed under contract, and, under the terms of those contracts, they were forbidden to discuss that development. We consequently adopted the strategy that, within reason, we would require hands-on experience with any system selected and with the software deemed critical to the completion of our work before we would agree to procure it.

We realized at this time, also, that we would have difficulty finding the full range of software that was required for the Klaten Survey processing if we procured a 16-bit microcomputer system. The appearance of the IBM PC at the close of 1981 gave 16-bit software development a great boost, but we found ourselves in the marketplace many months too early to be able to find, for example, data base management software the equivalent of dBASE II or Condor (available with 8-bit systems) for 16-bit systems. Nevertheless we knew that we required the memory capabilities of the newer 16-bit systems if we were to be able to use the Klaten COBOL routines without making major modifications to them. As a result, the design of several CP/M-based systems released early in 1982 employing dual processors appeared attractive to us because the dual processor would make it possible to use the older and more stable 8-bit software for many of the tasks and yet still have a system with the increased addressing capability of 16-bit svstems and access to the newer 16-bit software.

COBOL programs formed the heart of the Klaten Survey processing system, and we began the search for a good COBOL compiler at a very early date. The run-time requirements of the programs that we were to compile argued strongly for finding a compiler that was 16-bit microprocessor-based. Although two COBOL compilers available for 8-bit CP/M based systems were recommended to us, we continued our search hoping that we could avoid having to make major modifications to the programs to accommodate them to the memory restrictions imposed by these compilers. We had learned that both 8-bit COBOL "compilers" required run-time support systems resident in memory, placing even more severe restrictions on the size of programs that could be run.

It was early June when we first identified a COBOL compiler that appeared to be entirely adequate to meet our needs. MBP COBOL is

an implementation of the ANSI 74 COBOL standard for CP/M-86. It is, further, a true compiler. It requires primary storage of 80KB and at least 5MB of Winchester disk storage. Although the compiler was new, it was well-recommended and reports on the compiler's creation that appeared in ACM SigPlan Notices increased our confidence that it would perform satisfactorily. The selection of this software, even at this late date, strengthened the argument for our selection of the Intel 8088 or 8086 microprocessor chip and the CP/M family of operating systems.

We continued to look seriously at systems with proprietary operating systems up until a decision was finally reached. In most cases we did this because the systems appeared to be unusually well integrated or offered hardware features not commonly found on microcomputers. We realized, however, that there were strong advantages to selecting one of the more widely used operating systems, such as CP/M, the UCSD p-System, OASIS, or UNIX. The availability of more than one operating system was seen as an advantage.

The lack of a COBOL compiler argued against selection of the p-System in this case, although we were and are impressed by the concept it employs and by its portability. UNIX was at the time available only for Motorola 68000-based systems and we could not find such a system that would meet our software requirements. The field was therefore narrowed to CP/M and OASIS if we were to select an operating system that was not system-vendor specific. Both operating systems were available for 8-bit and 16-bit microcomputer systems. Although OASIS offered some very desirable features (such as record locking capability), CP/M offered a wider selection of software from a greater number of vendors. In addition, we learned of a modification of the multiuser operating system MP/M-86, MPM 8-16, that supported simultaneous operation of 8- and 16-bit microprocessors. This approach to bridging the gap between 8- and 16-bit systems seemed to offer needed flexibility and addressed many of the more serious problems that we were facing in meeting our software requirements.

17.1.3 General Considerations

In even more general terms, we were concerned about the possibility of upgrading any system that we were to procure. We hoped to be able to take advantage of developments in the technology by merely replacing parts of the system rather than having to procure another system altogether. We were encouraged by the possibilities offered on the S-100 systems that we looked at; new microprocessors could be used merely by replacing the CPU board, while memory and peripherals remained unchanged. Although we were not relying upon it, we were pleased that CompuPro, one of the vendors whose Intel 8086-based system we were considering, was said to be developing a Motorola 68000 board and UNIX operating system. We felt also that systems based on the more popular buses, such as Multibus or the S-100 bus, would make more products available to us if we found a need for them at a later date. We were especially concerned about the availability of a 9-track tape drive and about network

hardware. The availability of both of these products, while not a controlling factor in our decision, did influence us as we narrowed the list of systems for consideration to a workable number.

We chose to select 8-inch rather than 5 1/4-inch floppy disk drives. The IBM 3740 format for single-density, single-sided 8-inch disks is so widely used that it greatly increases the chance of being able to exchange programs and data using the floppy disk. While vendor software is generally available in the more common 5 1/4-inch formats, the 8-inch "standard" opens the door to an even wider software marketplace.

Local vendor representation and the availability of maintenance locally were also major considerations in the procurement process. We realized at the start that the procurement process would be lengthy and that the equipment would arrive at most 6 months before the completion of the study; we wanted to avoid delays caused by maintenance problems if we possibly could. We hoped that an authorized representative in the local area could help us with any maintenance problems. We found ourselves swayed as well by reports on the sturdiness and reliability of vendors' equipment found in the literature and received from users with whom we had spoken.

## 17.2 The Procurement Decision

As the deadline for a decision on procurement neared, the field of microcomputer systems under consideration was narrowed to the systems named in Figure 2. An aggressive effort to identify those systems with a working COBOL compiler further limited the number of systems under serious consideration to three, the Alanthus System 1000, the Altos ACS-8600 and the CompuPro CompuPro dual processor system.

| SYSTEM | MICROPROCESSOR CHIP | OPERATING SYSTEM |
|---|---|---|
| a. WICAT System 150 | Motorola 68000 | MCS |
| b. Alanthus System 1000 | Intel 8086 | CTOS |
| c. NCR Worksaver | Intel 8086 | CTOS (modified) |
| d. Fortune (1) | Motorola 68000 | UN.X |
| e. IBM Personal Computer | Intel 8088 | IBM-DOS (3) |
| f. Dual/68000 System 83 | Motorola 68000 | UNIX V7 |
| g. Universe 68 | Motorola 68000 | UNOS |
| h. 8086 Super-Micro | Intel 8086 | MS-DOS |
| i. Altos ACS-8600 (1) | Intel 8086 | CP/M-86, MP/M-86<br>OASIS-16, ZENIX |
| j. CompuPro | Intel 8085/8088<br>Intel 8086/8087 | CP/M-80, CP/M-86,<br>MPM 8-16 |
| k. Cromemco DPU (1) | Motorola 68000<br>Zilog Z80 | CROMIX |
| l. TRS Model 16 | Motorola 68000<br>Zilog Z80 | TRS-DOS (2) (3) |
| m. CODATA CTS-300 | Motorola 68000 | Merlin (UNIX V7) |

FIGURE 2. Microcomputer Systems Considered for Procurement.

(1) Advertised but still unavailable at time of procurement decision.
(2) No operating system for the Motorola 68000 chip at time of procurement decision.
(3) No multiuser support available at time of procurement decision.

The Altos ACS-8600, while an extremely new system, was attractive to us in part because of the Altos reputation secured through its track record with 8-bit systems and in part because of the operating system flexibility offered. The regional representative in New Jersey received one of the first of these new 16-bit systems in the week that our decision was to be made. He offered us the opportunity to come and try the system out but advised us that, while CP/M-86 and OASIS were promised, only the UNIX operating system was available on the system in his office. We reluctantly abandoned the Altos system since we could not be sure that the MBP COBOL compiler (a CP/M-86 dependent compiler) would be available for use. We were further concerned that no local representation was available.

The Alanthus System 1000, a system based on a Convergent Technologies machine, met most of our requirements. We found its Microfocus COBOL compiler to be limited and slow, but we believed that we could use it. Alanthus had local representation and was further willing to let us use one of their systems on occasion until our system was delivered. In addition, Alanthus utilized an impressively well-organized network operation and had integrated a 9-track tape drive into its system and demonstrated that it could be used successfully. It had the added advantage that, of all the systems we were considering, it alone was on the General Services Administration (GSA) schedule. (Actually, we learned later that WICAT was also on the GSA schedule, but WICAT's representative was apparently unaware of this.) That promised to speed up the procurement process for us. The Alanthus system failed to meet all of our requirements in the area of software. Although a CP/M emulator was planned for release in August 1982, we would be limited in the interim to software available for the operating system CTOS. Although a relatively complete set of compilers were available for CTOS, many of the software packages we had identified for use in our alternate Klaten processing work were unavailable, since packages like dBASE II ran only under CP/M.

The remaining alternative, CompuPro's CompuPro system, became a more and more attractive candidate for selection as we examined its features and capabilities. CompuPro's representative on the East coast, John Rost, was located in the Washington area and had been cooperative and helpful to us as we gathered information about the systems we were considering. He was able to answer many difficult questions that other vendors were unable to answer, and our experience in working with the system in his office was encouraging. The benchmark programs (prime number generator from BYTE Magazine written in various languages) that we tried to run at every vendor demonstration site compiled on the CompuPro system without difficulty and ran with some of the fastest times that we observed. Although we had said that we would require hands-on experience with all of the software that we considered critical to the project, we proceded without this experience with MBP COBOL on the word of another who was using MBP successfully on a CompuPro.

A number of articles mentioning CompuPro products helped to confirm our increasing confidence in the integrity, reliability, and

capability of the CompuPro system. The system not only used high quality components but included one of the better microcomputer power supplies. The fact that the system was S-100 bus-based meant that we would have access to a wide range of peripheral products including both streaming and 9-track tape drives as well as network hardware. The availability of a dual processor board supporting both CP/M-80 and CP/M-86 meant that we could have access to all CP/M software and still run MBP COBOL. The decision of Digital Research in making CP/M-80 and CP/M-86 disk files compatible meant that programs run under the two operating systems could use the same data base without the need of reformatting to meet individual operating system requirements. The availability of MPM 8-16, which not only provided a multiuser environment but offered the use of both 8-and 16-bit software without a change of operating systems, was a further incentive for selecting the CompuPro system.

Figure 3 shows the CompuPro hardware configuration that we selected. The first procurement order was filed on June 16, 1982. The system was operational under CP/M-80 and CP/M-86 in mid-October, 1982 and was complete on March 1, 1983. Much, but not all, of the lapse of nine months between order and delivery resulted from procurement policies peculiar to U. S. Government agencies. Other factors contributing to the delay that were directly related to aspects of the microcomputer marketplace are discussed below.

a. 20-Slot Enclosure (1)

b. 8085/8088 Dual Processor Board (2)

c. System Support 1 Board (3) (4)

d. Memory Manager (3)

e. Multiplexer 1-16 Board (3)

f. 512KB Low Power Static RAM (5)

g. Interfacer 4 Board (6)

h. Dual 8-inch Floppy Disk Drives with Disk 1 Controller Board (7)

i. Morrow Designs 20MB Winchester Disk with Disk 2 Controller Board (8)

j. Two Televideo CRT terminals (9)

k. Spectrum Graphics Board

l. Zenith 12" High-Resolution Green Monitor

m. C. Itoh Prowriter Model 1550 Printer (10

n. 8086/8087 Processor Board (11)

FIGURE 3. Hardware Components for the CompuPro Microcomputer System.

(1) The enclosure included a power supply for the system.
(2) The 8085 chip was to run at 6 MHz, the 8088 chip at 8 MHz.
(3) Required for the operation of MPM 8-16.
(4) The System Support card included a clock and an additional RS-232C serial port.
(5) All RAM was rated for 10 MHz operation and was designed to operate with either the 8-bit or 16-bit CPU chip. Procurement difficulties reduced the amount of memory actually delivered to 448KB.
(6) Included 3 RS-232C serial and 1 Centronics parallel port.
(7) Double-sided, double-density recording with just over 1MB capacity on a single floppy disk. The disk controller came with both CP/M-80 and CP/M-86 operating systems.
(8) A Pragmatic Designs disk from CompuPro was substituted for the Morrow Designs disk when delivery was made.
(9) One of these terminals was to be used primarily for word processing applications. A Model 950 terminal was selected for this function, and hardware to make the terminal function key compatible with WordStar was ordered. The other terminal supplied was a Model 925.
(10) The Prowriter has a 15-inch carriage capable of printing 136 columns at 10 cpi. It is a dot-matrix printer that operates at 120 cps.

(11) The 8086 chip could run at 10 MHz, but, when paired with the 8087 chip which runs at 5 MHz, its clock must be adjusted to 5 MHz as well. This board can be used with CP/M-86 only.

Despite the fact that software requirements strongly influenced our choice of hardware and operating systems, the selection of a full complement of software followed the hardware decision. Our choice of MBP COBOL has already been described. We chose to purchase compilers that could take advantage of the increased memory capacity of the 16-bit system and as a consequence we ordered BASIC, COBOL, FORTRAN, and Pascal compilers for the CP/M-86 operating system environment. Realizing that we might be forced on occasion to work outside the MPM 8-16 environment, we selected text editors for both the CP/M and the CP/M-86 operating systems. WordStar, a well-established and well-respected word processing package, was selected for use under CP/M and VEDIT-86, a full-screen text editor containing a powerful command-driven line editor, was selected for use under CP/M-86.

Terminal communications software, utility routines, and data base management software were all selected from the CP/M marketplace largely because comparable CP/M-86 software was not available at the time the procurement order was filed. We selected three of the stronger market entries for statistical software hoping that we could find the statistical capability that we needed among them. We also intended to compare these three quite different approaches to software packaging. Both MICROSTAT and the NWA STATPAK required MBASIC, a CP/M-based BASIC interpreter. SP-MICRO required yet another CP/M-based BASIC interpreter, CBASIC. The only tabulation package that we could locate that generated tables in a manner useful to us was Access/80. At the time, it was available only for use under CP/M.

Figure 4 shows the software that was finally selected for procurement to complete the work that was outlined for the system. Changes did have to be made in the software selection when the realities of the marketplace became clearer. In some cases these changes were to our advantage. For example, the program SP-MICRO was designed for use with CBASIC; so we ordered both CBASIC (for CP/M) and SP-MICRO. The version of SP-Micro supplied, however, was a fully compiled version that no longer required CBASIC support and ran much faster than the earlier interpreted version. In other cases these changes were to our disadvantage. For example, FORTRAN-86 proved unavailable and we were forced to accept FORTRAN-80 instead.

| | SOFTWARE PACKAGE | VENDOR |
|---|---|---|
| a. | MPM 8-16 Multiuser Operating System (1) | CompuPro |
| b. | CBASIC-86 | Digital Research |
| c. | MBASIC | Microsoft |
| d. | MBP COBOL (for CP/M-86 only) | MBP |
| e. | FORTRAN-86 (2) | Microsoft |
| f. | Pascal/MT+86 | Digital Research |
| g. | WordStar | MicroPro |
| h. | VEDIT-86 | CompuView |
| i. | Term II | Supersoft |
| j. | dBASE II | Ashton-Tate |
| k. | Access/80 | Friends Software |
| l. | SP-MICRO (now SL-Micro) | Questionnaire Service |
| m. | CBASIC | Digital Research |
| n. | NWA STATPAK (required MBASIC) | Northwest Analytical |
| o. | MICROSTAT (required MBASIC) | Ecosoft |
| p. | Supersort | MicroPro |
| q. | SuperCalc-16 | Sorcim |
| r. | Disk Doctor | Supersoft |
| s. | Universal Graphics Interpreter (3) | Compupro |
| t. | XMACRO-86 (4) | Digital Research |
| u. | C86 (5) | Computer Innovations |
| v. | Pearl III (5) | Pearlsoft Relational Systems |

FIGURE 4. Software Selected for Use on the CompuPro Microcomputer System.

(1) Note that the operating systems CP/M and CP/M-86 were already available to us, having been bundled with the CompuPro system's floppy disk drives.

(2) Microsoft's FORTRAN-86 proved to be unavailable for the CompuPro system and FORTRAN-80 was substituted.
(3) The Universal Graphics Interpreter was no longer supported by CompuPro when the order was filled.
(4) XMACRO proved to be unavailable when the order was filled.
(5) These packages were selected at a later date.

## 17.3 Difficulties Encountered in the Procurement and Installation Phase

Two factors resulting directly from the procurement policies of our agency had a considerble and adverse affect on the timely and successful installation of the system that we had ordered. First, we found it necessary to split the hardware and the software orders; and, once bids were received, the orders were awarded to different firms. One of the consequences of this was that whenever there was some doubt as to whose fault the failure of a particular software package was, the software vendor could always suggest that there was some peculiarity of the hardware or some switch that was incorrectly set causing the malfunctioning of his software. The hardware vendor could at the same time suggest that the software itself was faulty. This meant that, in cases that were difficult to adjudicate, the potential of a stalemate was clearly present, in which neither vendor would accept responsibility for the failure. Although cooperation of the vendors was sufficient to avoid this in our case, the situation is potentially disasterous and should be avoided if possible. Some of the delays in installation of the CompuPro system can still be attributed to this divi.ion of responsibility and the added burden that it placed on us to investigate difficulties and place pressure on the vendor that appeared to be at fault.

The second factor that adversely affected the procurement phase was the requirement that the lowest bidder be selected to supply the system. The result of this practice is that vendors deliberately cut the time that they are willing to devote to support in the problems that inevitably arise at the time of installation. When the vendor has not been paid for this time he is understandably reluctant to give it. As a result, some very helpful and perhaps even necessary support was consequently unavailable to us. We were again fortunate that, while the process was slow and we suspected that we were often a low priority, the vendors with whom we worked were cooperative and persistent; and the system was finally completed to our full satisfaction.

Although it is difficult to identify the effect precisely, these procurement factors influenced almost all of the problems that are described below and should be kept in mind as this report is read.

The first components of the CompuPro system arrived on September 22, 1982. The system was up and running under both CP/M and CP/M-86 with a single terminal and floppy disk drives only. The first problem that we encountered was that the vendor delivered a sealed system in which the screws closing the computer enclosure had been carefully covered with a compound designed to reveal tampering. He also kept all of the hardware documentation. We were warned by the vendor that any attempt to open the cabinet would void any future maintenance contract with his firm. We knew from the beginning that any arrangement that kept us from being able to swap or to add boards to the system was going to be unacceptable, but we were sufficiently taken aback at the idea that maintenance might be unavailable as a result that we merely voiced

our protest when the system was installed. It took us a day to overcome our intimidation and to call the vendor to task on this approach to system delivery. One of the two partners in the firm agreed that the action had been unethical, and several weeks later the partner at fault was bought out. In the meantime the "misunderstanding" about maintenance was cleared up. We decided against procuring a maintenance contract and have continued without maintenance coverage from the start. All system components were covered by the manufacturer's warranty (in most cases, for one year).

The arrival of the software vendor several weeks later to install the first delivery of software revealed that the system could not be brought up under MPM 8-16. As we made inquiries, we found that the version of MPM 8-16 provided by the software vendor was designed for use with an interface board (the Interfacer 3) different from the one included in our system. MPM 8-16 was returned to CompuPro and an updated version was obtained. A second attempt to bring the system up failed. This time conversations by telephone with CompuPro in California and the CompuPro representative in Washington revealed that the Interfacer 4 Board delivered to us was not properly configured for use with MPM 8-16. Arrangements were made for the board to be modified by John Rost, CompuPro's local representative. Rost made the modification without charge. MPM 8-16 has worked without difficulty from that time.

One of the next problems that we encountered was with the FORTRAN compiler. The software vendor acknowledged that, after having agreed to provide the Microsoft FORTRAN-86 compiler that we ordered, he was having difficulty obtaining it. Several months later we finally abandoned the attempt to acquire FORTRAN-86 and accepted Microsoft FORTRAN-80 instead. The problem resulted from the fact that Microsoft sells its 16-bit software only to system manufacturers. Microsoft further requires that the manufacturer contract to purchase 50 copies of the software. Although Microsoft had approached CompuPro on the subject of FORTRAN-86, CompuPro's relationship to Digital Research, Microsoft's primary competitor, apparently precluded any satisfactory arrangement. FORTRAN-86 was therefore unavailable to us. It may be that this package could have been bought through another manufacturer having a CP/M-86 system and a contract with Microsoft, but, in the interest of getting on with our applications, this path was not pursued.

Our attempts to install the communications software, Term II, were at first unsuccessful. The software vendor left the software for us even though it was not operational. In reading through the installation instructions included with the package, we discovered that some modification of the program would have to be made to accommodate the software to the interrupt-driven Interfacer 4 serial ports. The modifications required a thorough review of the documentation detailing the operation of the Interfacer 4 Board, as well as familiarity with the structure of the software provided by Term II. The patch to control operation of the serial port on the Interfacer 4 Board was written by our staff in 8080 assembler code

and was added to the Term II software. The modification took approximately one week of programmer time. Once it was complete the terminal software ran without difficulty.

The CP/M and CP/M-86 operating systems provided with the floppy disk controller used the Centronics port on the Interfacer 4 Board for printer communication. MPM 8-16 on the other hand used one of the three serial ports. This meant that we needed both serial and parallel connection capability on the printer. The original procurement order had specified the requirement for parallel connection only, and, before the printer was delivered, we approached the hardware vendor to inquire about the possibility of adding the serial capability.

Because the serial port on the printer cost an additional $100 we looked into the possibilty of substituting an Okidata 83-A printer that was delivered with both serial and parallel ports at a cost comparable to that of the C. Itoh printer. The vendor agreed to make the substitution and we attempted to integrate the printer with the system. The printer worked without fail under CP/M and CP/M-86 when it was driven off the parallel interface. It behaved erratically with MPM 8-16 when driven off the serial interface. The printer's successful operation with CP/M and CP/M-86 made us immediately suspicious of the MPM software, and we spent considerable time investigating the problem and talking with CompuPro personnel about the difficulty. One technician at CompuPro warned us that they had heard reports of difficulties with the Okidata printer, but we persevered for several weeks before taking the printer back to the vendor for examination.

The Okidata printer, when examined by technicians at the hardware vendor's offices, proved to have a faulty serial interface port. The technician proceded to test the other three Okidata printers in stock and found that all three had a similar problem. Arrangements were subsequently made for the purchase of the serial interface for the C. Itoh printer, and the C. Itoh performed successfully when attached to the system.

The Spectrum Graphics Board that was procured from CompuPro was delivered as requested, but its software complement, the Universal Graphics Interpreter, was unavailable. Although no explanation of the decision was offered, CompuPro had withdrawn its support of the package. We were able to obtain a copy of the software through a high school student in California who had known the author of the package. The hardware and software proved to work satisfactorily but there was a practical problem involved in the use of the hardware that has not yet been resolved. The graphics board is designed in such a way that the video monitor connector must be attached at the edge of the board. When the monitor is connected the computer enclosure cannot be closed. As a result, the graphics hardware and software have been used only under test conditions.

The second of the t terminals delivered, a TeleVideo 950, malfunctioned intermittently. As might be expected, the problem could not be demonstrated on demand, and it took some work to

persuade the dealer that there was a problem at all. The terminal was chosen specifically for the use of its programmable function keys with WordStar. To date, the vendor has not been able to complete the match between hardware and software, apparently as a result of problems within the TeleVideo terminal itself.

The final difficulty that we faced in the procurement process was the identification of a Winchester disk drive that could be successfully integrated into the system. Conversations with CompuPro in California suggested that the 20MB Morrow Designs disk utilizing a Fujitsu drive would be the best choice for the system in its current configuration. Inquiries at the time of procurement revealed that the Morrow disk was going to be difficult to obtain. In the interim, CompuPro itself had released a 10MB and a 20MB disk drive that could be used. Almost immediate delivery could be promised for the 10MB drive, but the 20MB drive was said to require a wait of two to three weeks. This wait gradually stretched to more than two months. The disk was finally procured from a CompuPro distributor on the West Coast and was successfully installed on February 9, 1983. An additional modification to the disk controller board was required for the use of MPM 8-16, and the vendor completed the modification at the end of February. With the installation of the Winchester disk, the Compupro system was complete, and the Klaten processing could begin.

## 17.4 Completion of the Work Scheduled for the CompuPro System

### 17.4.1 The Traditional Approach to the Klaten Survey

Once the terminal software package Term II was working, we began the task of downloading data and program files from the IBM 3081 at NIH. Transfer of the Klaten programs and data was completed in a single day early in November. Transfer of the data file, which consisted of 1988 records, required approximately 90 minutes; the full complement of programs took just over one hour. There were no problems with loss of data or faulty transmission.

Compilation of the Klaten CÓBOL programs was completed without difficulty once the modifications necessary to accommodate the programs to the MBP compiler were complete. The modifications included such things as changes to ASSIGN clauses, FD statements, AFTER ADVANCING clauses, COMP data descriptors, and the EXAMINE verb. We encountered only a few problems in using MBP COPOL. The first was an apparent bug in the implementation of "AFTER ADVANCING" that caused literally thousands of carriage return/line feed characters to be written to the file each time the command was issued. The second was an annoying but easily remediable problem that involved a difference between MBP and CP/M file structures. Standard CP/M text files use a carriage return character as the record delimiter with the delimiting character placed at the end of each record. MBP COBOL uses the carriage return character as a delimiter but it places this character at the start of each record. It was necessary to load every standard CP/M file that MBP was to use into a text editor, delete the first carriage return at the beginning of each file and add one at the end. A similar process

was required every time an MBP file was to be used as input to other CP/M packages.

The only serious problem that we had in compiling the COBOL programs was the apparent inability of MBP COBOL to work with files written in COMPUTATIONAL format. In the original mainframe version of the software, the first COBOL program read from a file of PIC X(80) records and generated a data file in PIC S9(9) COMPUTATIONAL. This format was used in all other programs. We were never able to uncover the reason for the problem, but subsequent programs were not able to read the output of the first program with complete accuracy. By merely changing the output in the first of the programs (and the input in all the rest) to PIC 9(6) fields, this problem was completely circumvented. There was no noticeable change in the performance of these programs as a result of the different data recording formats.

Once the Winchester disk drive was added to the system, the COBOL phase of the Klaten survey data processing effort was completed in five working days. Three of these days were devoted almost exclusively to analyzing the problems described above. The process was made more difficult by the fact that the COBOL compiler ran under CP/M-86 (largely because the compiler requires more memory that MPM 8-16 will allocate for it), and the text editor that was available under CP/M-86, VEDIT, continued to corrupt or partially destroy the COBOL source programs. VEDIT worked well with programs small enough to fit within the space it allocated in memory, but, when the size of the program exceeded that limit, the editor's paging functions caused a variety of problems, from crashing the operating system to merely obliterating sections of code. As a result, we were forced to boot the system up under CP/M-80 and use WordStar in modifying the COBOL programs.

Figure 5 shows the time required for program compilation and execution. Although the time sometimes seemed long, the performance of the CompuPro system with the MBP COBOL compiler was excellent and would have to be judged entirely satisfactory for general program development and production processing. We would expect that data files several times the size of those handled here could be processed without difficulty. The most likely problems to be encountered would be the increased difficulty of accessing the data files using a text editor as the files grow in size, and the problem of backing up the data files once the size grows beyond the capacity of the floppy disk (if that is the device to be used for backup).

| PROGRAM | COMPILATION TIME (in minutes) | EXECUTION TIME (in minutes) | |
|---|---|---|---|
| 1. Check-in program. Input: 1988 records. Output: 530 records, printed report. | 11 | 17 | |
| 2. Valid-value edit program. Input: 530 records. Output: printed report. | 9 | 11 | (1) |
| 3. Consistency edit program. Input: 530 records. Output: printed report. | 12 | 13 | (1) |
| 4. Record listing program. Input: 530 records, report requests. Output: printed report. | 3 | 2 | (1) |
| 5. Record update program. Input: 530 records, update requests. Output: 530 records, printed report. | 6 | 3 | (1) |
| 6. Recode program. Input: 530 records. Output: 530 records, printed report. | 7 | 2 | |
| 7. Table A Input: 530 records. Output: printed report. | 4 | 1 | |
| 8. Table B Input: 530 records. Output: printed report. | 3 | 4 | |

FIGURE 5. Approximate Times for Compilation and Execution of the COBOL Programs Comprising the Klaten Survey Data Processing System on the CompuPro system.

(1) The time of execution could vary considerably depending upon the number of requests (edit checks, transactions, etc.) made or the number of errors found.

Use of FORTRAN-80 for compilation of the one remaining program in the Klaten survey processing system proved to be difficult. The first problem encountered was an input buffer size restriction that meant that the 600-byte records would have to be broken into smaller units before they could be read in by the FORTRAN program. The READ instruction was modified to read in five 120-byte records. This meant that the final data file generated by the COBOL recode program would have to be reformatted so that each of the 530 records was divided into 5 separate records containing 20 variables each. The reformatting was fortunately easily accomplished using the utility Supersort, but the need for it was an unexpected development.

The second FORTRAN problem was more subtle and, due to the unusual symptoms, took several days over a two month period to unravel. The FORTRAN variance program compiled without error and was run with test data. The results were not correct, and so a number of statements were added to the program to print out intermediate results. The results changed but most were still incorrect. The addition of still more debugging statements again changed the variances. We were extremely concerned about the quality of the compiler at this point but were still baffled by the symptoms. We decided to change the internal storage requirements to make sure that all double precision variables were allocated as much space as possible. In doing this, we discovered the problem.

In the IBM FORTRAN compiler that had been used on the NIH IBM mainframe, any variable of the type INTEGER was automatically assigned a length of 4 bytes (meaning that values up to several billion could be accurately stored). Space could be saved by specifying counters and other variables containing only small values as variables of the type INTEGER*2, with the default being INTEGER*4. In FORTRAN-80 the type INTEGER defaults not to four bytes but to two. All variables in the program had fortunately been declared explicitly. Merely changing all references to include the length of the variable cleared up all of the errors, and the program ran, producing completely accurate results. When compared with the output of the program run at NIH, all differences could be accounted for by a difference in rounding (at the 6th decimal place) before printing the result in the specified format. We had no reason to question the accuracy of any result produced in this exercise.

Once corrected, the FORTRAN variance program required approximately 1 minute and 30 seconds to compile and link. A pass through the data file with requests for 18 variance calculations took six minutes.

The input file for the first of the programs in the system, the check-in procedure, had to be sorted before it could be processed. The utility package Supersort was used for this purpose. The 1988 records were sorted according to four 6-byte keys in 1 minute, 18 seconds. The data file as keyed in Jakarta, Indonesia, was in source code format; (with only those items recorded on the

questionnaire keyed and each response accompanied by an identifying number). The keyed data file required 193KB of storage space.

The actual data file being processed by each subsequent program consisted of approximately 350KB. While processing the data file, we were able to fill the 20MB disk to near capacity with the various intermediary and backup files. All program and data files were backed up on floppy disks and could be erased from the Winchester disk in order to relieve conjestion. The absence of date and time stamps for disk files (available with MPM 8-16 but not with CP/M or CP/M-86) was a disadvantage that required much more careful manual record keeping than might otherwise have been necessary. The ability to use a standard text editor to examine or modify the data files proved an enormous aid in debugging problems. The data files used for the COBOL tables could be accessed and used (with only minor modification) by both SP-MICRO and ACCESS/80, programs that run under a different operating system and that are written in different languages. This feature of the CP/M family of operating systems was extremely helpful to us in completing the work that was planned.

The output of all programs was functionally equivalent and, in most cases, was identical to the output of the programs originally run on the IBM 3033 system at NIH. We could discover no differences in the data file as processed on the CompuPro and on the IBM system. The tables produced by the CompuPro system were identical to those that had been produced at NIH. The major contrasts in the two processing jobs were the increased time for compilation and processing when using the CompuPro system and, much more noticeably, the slow speed with which printed output could be generated. Printing the listing generated by the COBOL compiler for the check-in program alone required 15 minutes. In most cases the CRT terminal is an entirely satisfactory alternative to printed output, but there are times, in program development especially, when a listing is almost invaluable. The multiuser and print spooling capability of MPM 8-16 was useful in this respect since printing could continue while other jobs were being processed. Operating the printer puts so few demands on the CPU that there is no obvious degredation in response time when print spooling is being used.

In sum, use of the CompuPro in a traditional approach to data processing of the Klaten survey data was a complete success. Completion of this task was enormously encouraging to us and has undoubtedly shaped our positive evaluation of the potential of microcomputer systems.

17.4.2 <u>An Alternative Approach to the Klaten Survey</u>

In this second phase of testing, we began with the source coded data file that had been keyed in Jakarta. This approach to keying had been chosen because the questionnaire was designed in such a way that most of the questionnaires would contain large blocks of unanswered questions and source coding can reduce the keying effort involved in keying data in such situations. Unfortunately the

unusual format of this data did not lend itself to processing by any of the packaged software available to us. Each of the 80-character records on the keyed file included a household identification number followed by pairs of numbers representing the number and value of a response found on the questionnaire. We found it impossible to avoid writing a custom program at this point, and the program was written in Pascal. Actually, the need for this program could have been easily eliminated at the start since data could have been keyed in a format that would have been immediately useable by dBASE II or other packaged software using standard CP/M text files.

This file reformatting program was designed to check for illegal values among the numbers identifying variables and to check for attempts to record the same variable twice in forming a single household record. The program which consisted of 197 lines of Pascal code compiled and linked in less than one minute. The sorted data file of 1988 records was processed in just under 5 minutes. The output file was similar to that produced by the first of the COBOL programs but it included 70 non-interview records, bringing the file up to a total of 600 records. The difference in speed of processing was probably a mix of different code efficiencies and different numbers of checks and reports performed.

The first major concern in processing the file was to determine that all households in the survey were accounted for and that all were correctly identified. We decided to use the facilities of dBASE II to perform this check and consequently prepared to install the data file as a dBASE II data base. A number of limitations imposed by dBASE II presented challenges. First, the package would allow only 32 variables per record. We had a file with records containing 100 variables. For this check we did not need to use all of the variables so the limitation was an inconvenience but not a serious problem. The first 20 variables in each record were correctly described; the remaining 80 were simply ignored. The data base was constructed in less than five minutes once the planning and design were complete. Coding and debugging of a program to check for missing questionnaires and invalid identifiers using dBASE II commands took approximately 45 minutes. The program was able to pass through the entire data base in 1 minute and 30 seconds. There were no missing questionnaires but one identifier had been incorrectly keyed. The edit mode of dBASE II was used to correct the error and the file was written out as a standard CP/M file using a dBASE II command.

In the next step, non-interview records were removed from the corrected data file produced by dBASE II using the SELECT option available in the statistical package SP-MICRO. A command file was prepared for SP-MICRO using WordStar and, in two passes, the data file was divided into two parts, one containing 70 non-interview records, the other containing the records of the 530 households with completed questionnaires. Each pass through the file took approximately four minutes. A frequency distribution of the reason for non-response was generated in one of the passes.

The next problem that we had to deal with was that of checking the data for validity and consistency. The powerful command language supported by dBASE II appeared to be adequate to the task, and so the modified data file containing the records from 530 responding households was once again placed into a dBASE II data base. The processing of this survey was not originally designed to be completed within the restrictions imposed by dBASE II, but there were no checks written that could not be completed under it. The restructuring of the data base so that different combinations of variables could be examined and modified would have been tedious, but it could have been accomplished.

We chose to implement only a sample of the range and consistency checks, limiting these to checks dealing with the first 20 variables. We encountered no difficulty in implementing these checks. The dBASE II command files ran quickly. The consistency edit program included six tests consisting of 18 comparisons performed on each of the 530 household records. The command file was able to process the entire data set in 2 minutes, 15 seconds. All of the updating resulting from the valid-value and consistency edits could have been managed easily using dBASE II in its editing mode. Instead, at this point we returned to the corrected data file that had been created using traditional processing methods in order to proceed with our examination of statistical and tabulation software.

Using WordStar we next created the commands for ACCESS/80 that would generate the tables that had been produced earlier with custom COBOL programs. This task took some time, since the software was new to us, but in half a day we had generated a table that was the functional equivalent of Table A. After this table was complete, additional tables could have been produced very quickly. Our major concern had been that of weighting the data, but it proved to be straightforward since ACCESS/80 allows the summation of what are effectively recoded values, meaning that the weight had been applied. The tables produced were not of publication quality, but they were entirely adequate for use by an analyst and could have been retyped for production after minor editing. There is, unfortunately, no facility in ACCESS/80 for capturing these tables in machine readable format.

It was easy to use SP-MICRO with the corrected data file and its use would have proven helpful in the original mainframe processing system in resolving the questions that inevitably occur when tables generated produce what appear to be incompatible results. In frequency distributions and cross tabulations SP-MICRO does not sum values but merely counts the occasion of specific responses. This fact, coupled with its inability to work with weighted data, meant that SP-MICRO's value in the analysis of this survey was limited.

Modification of the data file to accommodate the format requirements of NWA STATPAK was a tedious and time-consuming task. NWA STATPAK expected a space between the value of every variable in the file. Although it proved possible to reformat the file using Supersort, the process involved more than a dozen steps and took

several hours to complete. It would have been easier to have used a custom program to perform this task. The better approach, however, proved to be to use Supersort to select those variables that were of interest from the original file and place them in a separate file in a format readable by STATPAK. This could be accomplished with relative ease using Supersort as long as the number of variables was small (no more than 32).

NWA STATPAK, unlike SP-MICRO which processes a set of commands saved in a disk file, is an interactive statistical package. The questions asked for the generation of a simple frequency distribution, especially those concerning the structure of the data file, were sufficiently unclear or confusing to require repeated returns to the manual during processing. The procedure was considerably slower than its SP-MICRO counterpart (though speed was still not a problem), not only because STATPAK relies upon MBASIC, but also because it requires two passes through the file to produce a frequency distribution. The first pass is made to determine the upper and lower limits of the values of the variable to help in specifying limits in a grouped frequency distribution. Since we used very large unique numbers to represent blanks and missing values, the information that STATPAK gathered in the first pass was entirely useless because the actual upper limit was obscured by the coded blanks and missing values.

The task of reformatting the data file and preparing it for use with MICROSTAT was sufficiently formidable that we never attempted it. The documentation appeared adequate to support an effort to write a BASIC program to generate the necessary header and data files but we judged it not worth the effort. There were no features available in MICROSTAT of interest to us that were not already available in the other two packages. MICROSTAT's main advantage is that it is completely menu-driven.

The one remaining task was that of calculating variances, and it became clear that none of the statistical packages available to us was sufficiently flexible to perform the calculations that had to be made. Sampling had involved the use of clusters, and variances were to be minimized by using the differences in the responses of consecutive clusters of households meeting specific requirements (such as user of electricity with monthly expenditure within a specified range) rather than the household responses themselves. These differences were confined to a single stratum and could not be calculated across stratum bounds.

It might have been possible to have used the packaged statistical software by forming individual files containing the consecutive differences by stratum and using these files as input to the statistical routines. The results generated would then have had to be multiplied by appropriate weighting factors to complete the calculation. Since more than 1000 individual calculations were required, it would have been necessary to create more than 1000 files for input to the statistical packages. While this could have been done, it would have required custom software; and the effort involved would have been far greater than that required to

calculate variances using a custom program such as that developed in FORTRAN by the original Klaten survey processing effort. Since we had already determined that the use of such a custom program was entirely feasible, the only conclusion drawn from this impasse was that packaged software does not and will not address every need. There will be times when the development of a custom program to perform a highly specific task will be more expedient than attempts to use the facilities of packaged software.

Our overall assessment of the potential of packaged microcomputer software for dealing with processing requirements typical of surveys similar to the Klaten study was favorable. It should be possible, with some advanced planning, to design processing systems that would bypass much of the traditional custom programming effort and utilize instead the capabilities of packaged software. The effect of this change in process may be a shift of work from programmers to analysts overseeing the processing effort, but there should still be a net savings in effort. Despite the fact that packaged software handles many of the more tedious jobs of programming with ease and accuracy, users of this software will require training and will need to have some of the same general skills that are required of programmers and systems analysts. Program menus can attempt to enforce logical procedure but they are no substitute for logical and planned activity in data processing. Statisticians and data analysts, as a result of the capabilities of packaged software, may be the ones to perform tasks that have previously been performed by programmers and systems analysts, but the more difficult parts of this work (planning and design of process) will still remain, and there will continue to be substantial demands for training.

### 17.4.3 Additional Tasks

Following the successful completion of the Klaten survey processing, we wanted to address the question of reasonable limits to file size for processing. Data from a much larger survey performed as part of a health project in Jamaica was downloaded from NIH. The file consisted of 4,104 records containing 90 variables. Although transferred in blocks of less than 1000 records (as a result of limitations placed on us by the IBM mainframe at NIH), the completed data file required 1.5MB of storage. A file of this size could not be backed up on floppy disk, and only the constituent parts were backed up. The entire data file could be created from these parts by a simple file concatenation process supported by CP/M. We found also that files of this size were difficult to handle and examine. Moving about in a file of more than 500KB using a text editor is extremely slow and hazardous. We were able to crash the system completely on several occasions with a request to WordStar to find the end of the file. Selected variables from all 4,104 records were loaded into a dBASE II data base in less than two minutes and the dBASE II editor had no more difficulty working with this number of records than it did with the 530 records of the Klaten file. SP-MICRO also performed well with this file. Frequency distributions for six of the 90 variables were prepared in just under 10 minutes in a busy

multiuser environment. While file handling with data sets of sizes well over 1MB may be time-consuming and may require special effort in insuring that backups are made and are current, a file of 1.5MB is still well within the capabilities of the CompuPro system.

In addition to our experience with this large file, we worked with two other large data bases that had been created at NIH for use in our work on this project. A file consisting of 1400 variable length records containing information and references used in the preparation of this document was transferred to the CompuPro system and installed as a data base under dBASE II. In addition, a list of approximately 1300 software packages was downloaded and installed under dBASE II. We developed an interactive data base inquiry system for the first of these files using dBASE II commands that proved useful. The report capabilities of the software package, too, were helpful in accessing the information included in both of the files.

More than one ISPC manager used SuperCalc-86 to develop project accounting systems. Almost no support was required from the data processing staff for this work. One user found that moving beyond the most simple procedures to a relatively complex report introduced errors in the calculations that would not be immediately obvious to someone reviewing the report, and that could be cleared up only by a systematic and careful reorganization of the spreadsheet's design. A great deal of care should be taken in the use of this packaged software if anything more than the most straightforward reports are desired. Since normal program testing may be completely bypassed by unsophisticated users of this software, output should always be considered suspect.

The CompuPro system was also used for word processing applications. Much of this report, and all of this chapter, was prepared on the CompuPro using WordStar running under MPM 8-16. The capabilities of the package are impressive and should be entirely adequate to meet the needs of most statistical offices. Greater printing capability than that provided for in this CompuPro configuration would be desirable if heavy word processing usage were planned.

## 17.5 <u>Summary of Our Experience With the CompuPro System</u>

Once completely integrated and installed, the CompuPro hardware has performed without failure or problem. We have been impressed with its reliability and performance. We know from our experience in working with an Apple Computer that problems such as those we experienced in the integration of the system were by no means unique to CompuPro, and they were, in the end, well handled by CompuPro.

The CP/M, CP/M-86 and MPM 8-16 operating systems proved entirely adequate for the work that we were required to complete, and we believe we were well served by the CP/M family of operating systems. In the world of microcomputing it is a great advantage to be able to work with the same data files under different operating systems. Digital Research has made this possible through the use

of a common file structure. We were also able to complete our work because we were able to use software developed for more than one operating system. dBASE II does not currently have a CP/M-86 equivalent; MBP COBOL does not have a CP/M equivalent. Both pieces of software proved invaluable to us in working with the same data file.

We were further satisfied by the COBOL, FORTRAN, and Pascal compilers that we used to complete our work. Although we found problems, none was insurmountable. In most cases the compiler software worked without problem or error. Other packaged software that we used varied in quality. Supersort, Access/80, and SP-MICRO performed predictably and correctly in every instance. WordStar and dBASE II were extremely reliable and were responsible for only a few unexplained problems in several months of very heavy use. The newer software packages, SuperCalc-86 and VEDIT-86 for example, had a number of problems that were both prominent and annoying.

Our processing work on the CompuPro system was entirely successful and has left us with a strongly favorable impression of the potential of microcomputer systems. The CompuPro performed faultlessly in its support of both program development and execution. There were no delays in processing caused by factors other than our unfamiliarity with the software packages that were being used. While the limitations (on such things as number of variables that may be included in a file) imposed by packaged software may be severe, careful planning of data processing with these limitations in mind may make it possible to exploit the advantages of this software, nevertheless. Secondary storage capacity, rather than speed, is likely to be the primary limiting factor of the usefulness of these systems in national statistical offices.

# CHAPTER 18: THE FUTURE OF ISPC SOFTWARE ON MICROCOMPUTERS

## 18.1 CONCOR and CENTS 4

ISPC has developed statistical software for use on mainframe computers and minicomputers. The most popular packages currently distributed are CONCOR and CENTS 4. CONCOR (CONsistency and CORrection) is an editing and imputation system. It is a general purpose package for the identification and correction of invalid or inconsistent data in various types of censuses and surveys. CENTS 4 (CENsus Tabulation System) is a tabulating and reporting system. It is a flexible and easy-to-use package for generating reports and cross tabulations. Both systems are designed to aid in statistical data processing activities that typically occur in the national statistical offices (NSO's) of developing countries.

With the increasing popularity of microcomputers and the emphasis on placing microcomputer equipment in NSO's, several issues regarding CONCOR and CENTS 4 need to be reevaluated. Research undertaken by ISPC and discussed in this paper has shown that it is feasible to use microcomputers for some survey processing as well as other activities that might be undertaken in NSO's. The issues regarding the use of CONCOR and CENTS 4 on microcomputers are:

-- Is software currently available for microcomputers that can do what CONCOR and CENTS 4 do?

-- If no comparable microcomputer software exists, is it feasible to implement the approach that CONCOR and CENTS 4 provide onto a microcomputer? Does it make sense?

-- If it is feasible to use CONCOR and CENTS 4 on a microcomputer, how should CONCOR and CENTS 4 be implemented on those machines?

These issues will be addressed by first describing CONCOR and CENTS 4, comparing them to the existing microcomputer software, and then discussing potential implementations.

CONCOR, as mentioned earlier, is a general purpose software package for the identification and correction of invalid or inconsistent census/survey data. It is capable of detecting errors in the structure of responses in a questionnaire, the errors in the range of responses to an individual question, and inconsistencies between responses to different questions. It is also capable of correcting problems detected and generating "error-free" output files that are identical in format to the original input. CONCOR can produce comprehensive statistical reports which summarize processing at different levels and in different organizations as requested by the user. These summary reports are created upon request.

CENTS 4 is a generalized tabulating and reporting package geared toward housing and population data; however it can be used to process other kinds of statistical data. The reports produced are of publication quality, since the user has almost total control

over the format of the printed report. Matrix calculations can be performed on tables after they are tallied. Tables can be multidimensional crosstabulations with more than one universe definition per report. Up to five levels of geography can be defined. Hierarchical files can be processed as input. The system allows the user to take maximum advantage of memory by maintaining the lowest level of tally blocks in memory. It then consolidates tally blocks in a separate step to form summarized tables for different levels of geography. CENTS 4 provides an easy-to-use and efficient means of producing tables and reports.

Both CONCOR and CENTS 4 combine program generation and interpretation techniques. They generate COBOL programs which are used to process the original input data file. The summary output information is then processed by interpretive routines that create the final reports. Thus, the program used to process the original input file is an efficient COBOL program; and where generating and compiling COBOL code would probably be less efficient, interpretation is employed.

There is no software package running on microcomputers that can do what CONCOR does on mainframe computers and minicomputers. Systems such as dBASE II with its command language and ISIS with its range checking and transformation features provide editing capability, but provide no easy means of summarizing the edit processing. No system available on microcomputers can automatically provide the reports summarizing the edit tests. The reports by questionnaire, edit command, or by variable which are produced by CONCOR are impossible to replicate using existing microcomputer software packages.

There are some software packages for microcomputers that approach the capability of CENTS 4. Among these are spreadsheet packages, tabulation software, and data base management software. All of these software packages offer features of CENTS 4, but each falls short in some way.

## 18.2 Existing Packages and their Shortcomings

### 18.2.1 SuperCalc (spreadsheet software)

SuperCalc is considered a "spreadsheet" package. This means that it allows the user to design table reports on the CRT and then insert rows and columns of numbers into the tables. Matrix calculations such as those found in CENTS 4 can be incorporated; in fact, the automatic recalculation of totals, percents, etc., is considered a major selling point of the "spreadsheet" software. The cosmetics of the printed report are quite nice, although SuperCalc has some weaknesses regarding its handling of decimal values.

The major difference between SuperCalc and CENTS 4 is that CENTS 4 is designed to read and process records from large data files in a sequential manner. SuperCalc, on the other hand, requires that all data be loaded into its array of 254 rows and 63 columns at some

point in the process of preparing a tabulation. The facilities for performing this loading operation are limited, and the management of large data files for use with SuperCalc is difficult. Also, SuperCalc offers no batch capability for multiple reports. Each report must be loaded by the user by specifying commands at the keyboard. If many tables were to be produced, this activity could become tedious. CENTS 4 produces tables by matching table matrices to lists of text and calculation commands. In this way, CENTS 4 avoids the manual intervention needed by SuperCalc. SuperCalc also has a limit of 255 lines to a table. CENTS 4 has no limits on table size and allows over 5000 table cells.

### 18.2.2 ACCESS/80 (tabulation software)

ACCESS/80 has many of the tallying features available in CENTS 4. It can produce tables using weighted data, can simulate area breaks, and can perform row and matrix calculations. Its command language is easier to use than CENTS 4. However, ACCESS/80 is not as flexible as CENTS 4 in universe selection for tables and in flexibility in the format of the printed report. Only one set of universe definitions may be defined per report using the FOR command in ACCESS/80. Also, ACCESS/80 cannot look at more than one record to make its universe selection decision. All tables are stored in memory. CENTS 4 conserves memory by writing out table blocks as the required geographical reporting area level changes. This means that more tables can be produced during one execution of CENTS 4 than during one execution of ACCESS/80. The user does not have as much control over the cosmetics of the reports that ACCESS/80 generates compared to the flexibility provided by CENTS 4. CENTS 4 allows stubs on the right side of a page and can automatically insert geographic names into report titles, among other features. ACCESS/80 cannot produce publication quality reports.

### 18.2.3 dBASE II (data base management software)

dBASE II is a data base management system for microcomputers. The cosmetics of its printed reports are adequate since the system provides the user with good control over formatting the report. However, the CP/M version of dBASE II examined by ISPC staff members only allows for 32 primary variables per input file for a maximum of 64 variables. Also due to the complexity of dBASE II's command language, it might be almost as easy to write a tabulation application in a programming language such as Pascal or COBOL. Between the limitations on the number of variables and the complexity of the language, dBASE II does not look promising as a match for CENTS 4 on microcomputers.

### 18.2.4 Other Software

ISPC staff members examined several other packages available on microcomputers. Packages such as ISIS (Interactive Statistical Inquiry System), SL-Micro (Statistical Language for Microcomputers) and MICROSTAT were also examined. None of these produced publication quality tables. Both ISIS and SL-Micro produced tables

that looked similar to SPSS crosstabulations, and both could only create one variable by one variable crosstabulations. ISIS provided no easy means of universe definition. None of the software packages evaluated provided publication quality, multidimensional, multiuniverse reports equivalent to those possible with CENTS 4.

18.3 Installing CONCOR and CENTS 4 on Microcomputers

As part of this study, ISPC performed survey data editing, tabulating, and statistical analysis on a microcomputer. In the past, this survey was processed using a mainframe computer. ISPC proved that indeed some survey processing could be done on microcomputers. Microcomputers currently have the capability of processing some surveys that may be undertaken by NSO's, and there is already significant interest overseas in downloading processing activities onto these machines. This is largely due to the cost of microcomputers being significantly lower than the cost for minicomputer and mainframe equipment. There is a need for good editing and tabulating software for microcomputers, and there is no software on microcomputers that is comparable to CONCOR or CENTS 4.

There are three possible approaches by which ISPC software could be implemented on microcomputers. These approaches are:

-- Direct download of existing ISPC software,

-- Download of existing ISPC software and add-on of a user-friendly interface, or

-- Complete rewrite of software.

Each of these approaches has inherent advantages and disadvantages. These approaches will now be examined in more detail. The issue of portability is important in each of the suggested alternatives.

18.3.1 Portability

Portability refers to the ease or difficulty with which software is transferred from one machine to another and made operational. Obviously the programming language in which software is implemented has a tremendous impact on the portability and efficiency of that software. Software written in Assembly language for a specific machine may be efficient, but Assembly language has no standard and is not very portable. FORTRAN has an ANS standard, but has very inefficient input/output processing. ISPC uses the 1974 ANS COBOL standard for implementing most of its software, and only the most widely accepted components of that standard are used. COBOL is available on most machines and its input/output processing is reasonably efficient.

Portability is a serious issue to consider when implementing CONCOR and CENTS 4 on microcomputers. One of the major tasks undertaken by ISPC is the maintenance and upgrading of both of these systems. When modifications to the software are required, incorporation of

these modifications to master versions of both CONCOR and CENTS 4 are done. ISPC is also responsible for conversion of the software for installation on other computer systems, and this gives ISPC a concerned interest in the portability of software developed. If both CONCOR and CENTS 4 were directly downloaded, then updates to the mainframe versions could easily be added to the microcomputer version. If any substantial modification were made to the microcomputer version, it would probably be necessary to maintain two separate versions of CONCOR and CENTS 4, one for the mainframes and minicomputers, and one for microcomputers. This would add considerable cost to ISPC's software support activities. ISPC currently expends significant time and resources converting its software to run on specific vendor's machines.

There are many inherent advantages in ISPC developing portable software. In the past, the majority of hardware overseas was IBM. Although IBM is still the predominant hardware, other vendors are gaining popularity overseas. The policy of developing portable software allows easier installation of ISPC's software on a wide variety of computer equipment. The software is not tied into one vendor's hardware or compiler. The skills developed while transferring software to different machines are beneficial when helping users in LDC's in hardware selection and statistical data processing efforts on different machines.

Developing portable software also has some disadvantages. The code must be written using the most standard features of a programming language. This means that some more efficient commands available in the language need to be avoided. ISPC does not use less generally accepted COBOL verbs such as ALTER, INSPECT, STRING, UNSTRING, and ACCEPT. Code tends to be more verbose since special characters are generally avoided. For example, the phrase "IS LESS THAN" will be used instead of "<". As was mentioned earlier, a considerable amount of time can be expended even under the best conditions converting software to run on other machines. Developing and converting portable software is an expensive and time-consuming task.

On microcomputers, there may be an easier method of achieving portability without needing to modify software for each vendor's machine. In the mainframe and minicomputer world, each machine generally had its own operating system and compilers. In the microcomputer world, there are some widely accepted portable operating systems and accompanying compilers that can run on several different vendor's machines. Among these portable operating systems are CP/M, CP/M-86, p-System, MS-DOS and UNIX. CP/M is the most popular portable 8-bit microcomputer operating system and MS-DOS is the most popular 16-bit microcomputer operating system. Software portability for a number of different machines could be easily achieved by developing software for a specific compiler on a portable operating system. Rather than modifying the software for each user's compiler or operating system, the end-user could just run the software under a specified operating system and compiler on the user's own machine. It is not

uncommon for more than one operating system to be used on a microcomputer system.

There are many advantages to selecting a specific operating system and compiler for implementing a software package. If a popular operating system were selected, for example MS-DOS, the software would immediately be available on a very wide selection of 16-bit microcomputers. MS-DOS runs on the IBM PC and many IBM look-alikes. Many other vendors offer MS-DOS as an operating system to maintain compatibility with the IBM-PC. If the microcomputer vendor offers a good implementation of MS-DOS, compilers for MS-DOS will transfer to that vendor's system. This means ISPC could develop a software package written using the full extensions of a compiler knowing that the same compiler will be available on the end-user's machine. In fact, since the price of microcomputer operating systems and compiler software is relatively low, these could be distributed for an additional charge as part of the software package.

This concept of developing software around a specific operating system and compiler has one major disadvantage. Since it restricts the use of the software to one specific operating system and compiler, the software would need to be converted for use on another operating system or compiler as is done now with ISPC mainframe and minicomputer software. This is why selection of a good implementation language for the software is important. Eventually it would be desirable to transfer the software to other operating systems and compilers.

### 18.3.2 Possible Approaches to Implementing ISPC Software on Microcomputers

#### 18.3.2.1 Direct Download of Existing ISPC Software

This is the most simple approach to implementing ISPC software on microcomputers. In this approach, the software currently running on mainframes and minicomputers is downloaded to the microcomputer using communications software. The software is then modified to conform to the microcomputer COBOL compiler's requirements. The standard system benchmark is then run to test the installation of the software, and a command procedure is developed for executing the system.

This approach has cost benefits. Since it only requires software modification and not software development, the development costs are relatively low, as is the amount of time required. Only one version of the software would need to be maintained, and differences between mainframe and microcomputer versions could be documented in the master version stored on the mainframe computer. The documentation for the microcomputer version would be the same as for the mainframe version, and no retraining of current users would be required.

The major disadvantage of the direct download approach is that it does not take advantage of the interactive features avail.ble on

microcomputers. CONCOR and CENTS 4 are essentially programming languages. The user's commands are compiled and the input data file is processed in batch mode. Interactive processing of the user's commands would improve program development. Also, a direct download of the software would result in COBOL being the implementing language since COBOL is the current implementation language of ISPC software. COBOL might not be the best language for implementing software on microcomputers.

There are some issues that need to be addressed before attempting the direct download approach. Some of the CENTS 4 and CONCOR programs may be too large to run on a microcomputer. One of the CENTS 4 program modules contains 9500 source lines. This is too large for the CP/M-86 VEDIT editor and the CP/M WordStar word processing packages to easily edit. It may be necessary to separate a large program into several smaller files, perform the text editing required, and then concatenate the smaller files into one large file that can be processed by the COBOL compiler. This can make software development even more tedious. It is unknown whether microcomputer COBOL compilers can process a source program this large. Although vendors claim their COBOL compilers support relative access files, this has also not been tested by ISPC staff.

18.3.2.2 Download Existing Packages and Add User-Friendly Front-end

Another approach to implementing ISPC software packages on microcomputers is to first download the existing software onto a microcomputer and then write a user-friendly front-end routine to interface between the software and the user. This idea has merit since it is an adaption of already existing mainframe software for a microcomputer with an interface that takes advantage of the user-friendly interactive features of microcomputers.

CENTS 4 would lend itself quite nicely for processing using a user-friendly interface. Through a series of screens, the system could guide the user through the production of a report. The following is an example of a series of screen and user responses that would result in an age by race crosstabulation. User responses are underlined:

SCREEN 1

```
-------------------------------------------------------------------
|                                                                 |
|          Specify:                                               |
|                                                                 |
|    1.   To create new command file                              |
|    2.   To update command file                                  |
|    3.   To create new data dictionary file                      |
|    4.   To update data dictionary file                          |
|    5.   To process a report                                     |
|    6.   To end processing                                       |
|         User Selection:  3                                      |
|                                                                 |
-------------------------------------------------------------------
```

SCREEN 2

```
              Data Dictionary File Processing

        Enter filename:  B:POP.DD

        Creating B:POP.DD....
        File created.  Do you wish to continue? (Y/N): Y
```

SCREEN 3

```
              Data Dictionary File Processing

 Variable name:  AGE
 Heading when used as column variable.  Default is <AGE>:__
 Heading when used as row variable.  Default is <AGE>:__

 Enter value label definitions.  Please indicate range of
 values by specifying <lower-limit> TO <upper-limit>.
 Discrete values can be separated by commas and/or spaces.  The
 entry "Values:ESC" indicates all other values are tabulated
 into this group.  Terminate list with a blank line.

 Value label #1: _0-19 YEARS_   Values: _0 TO 19_
 Value label #2: _20-39 YEARS_  Values: _20 TO 39_
 Value label #3: _40-59 YEARS_  Values: _40 TO 59_
 Value label #4: _60+ YEARS_    Values: _60 TO 99_
 Value label #5: _UNKNOWN_      Values: _ESC_
 Value label #6: ____________

 Width of field: _2_ Type of field (b(inary),c(har),n(um)): _n_
 Variable from input file? (Y/N): _Y_ Beginning column: _43_

 Define another variable?  (Y/N): _Y_
```

SCREEN 4

```
-------------------------------------------------------------------
|                                                                 |
|            Data Dictionary File Processing                      |
|                                                                 |
| Variable name: _RACE_                                           |
| Heading when used as column variable.  Default is <RACE>: ___   |
| Heading when used as row variable.  Default is <RACE>: ___.     |
|                                                                 |
| Enter value label definitions.  Please indicate range of        |
| values by specifying <lower-limit> TO <upper-limit>.            |
| Discrete values can be separated by commas and/or spaces.  The  |
| entry "Values:ESC" indicates all other values are tabulated     |
| into this group.  Terminate list with a blank line.             |
|                                                                 |
| Value label #1: _CAUCASIAN_       Values: _1___                 |
| Value label #2: _BLACK_____       Values: _2___                 |
| Value label #3: _OTHER_____       Values: _ESC_                 |
| Value label #4: ___________                                     |
|                                                                 |
| Width of field: _1_ Type of field (b(inary),c(har),n(um)): _n_  |
| Variable from input file? (Y/N): _Y_ Beginning column: _63_     |
|                                                                 |
| Define another variable?  (Y/N): _N_                            |
|                                                                 |
|     Returning to main menu                                      |
|                                                                 |
-------------------------------------------------------------------
```

SCREEN 5

```
-------------------------------------------------------------------
|                                                                 |
|            Specify:                                             |
|                                                                 |
|     1.  To create new command file                              |
|     2.  To update command file                                  |
|     3.  To create new data dictionary file                      |
|     4.  To update data dictionary file                          |
|     5.  To process a report                                     |
|     6.  To end processing                                       |
|         Selection:  1                                           |
|                                                                 |
-------------------------------------------------------------------
```

SCREEN 6

```
Command File Processing

Enter filename:  B:XTAB.CF

Creating B:XTAB.CF....
File created.  Do you wish to continue?  (Y/N): Y
```

SCREEN 7

```
V(iew) I(nput) U(p) D(own) F(irst) L(ast) C(hange) S(earch)
Q(uit) M(odify) R(emove) N(ext) P(revious) X(transfer)

Enter data dictionary name:  B:POP.DD
I
Enter report processing commands.  Terminate list
by pressing ESC key.

     1.  Report Age by Race
     2.  ESC

Q
Save changes?  (Y/N):  Y
Saved

View report format?  (Y/N):  Y
```

SCREEN 8

```
(test view)
Age by Race

RACE

AGE            TOTAL      CAUCASIAN      BLACK       OTHER

  TOTAL        999,999     999,999      999,999     999,999

0-19 YEARS     999,999     999,999      999,999     999,999
20-39 YEARS    999,999     999,999      999,999     999,999
40-59 YEARS    999,999     999,999      999,999     999,999
60+ YEARS      999,999     999,999      999,999     999,999
UNKNOWN        999,999     999,999      999,999     999,999

Modify report layout? _N_

End of report viewing.  Generate report? _Y_
```

SCREEN 9

```
Enter input data filename: B.POP.TXT

Generating tabulation program....
Compiling tabulation program....
Executing tabulation program....
Tabulation program complete.
   Input records read = 6,713
   Reports generated = 1

View Report?   (Y/N): _Y_
```

SCREEN 10

Age by Race

| AGE | TOTAL | RACE: CAUCASIAN | BLACK | OTHER |
|---|---|---|---|---|
| TOTAL | 6,713 | 1,043 | 5,583 | 87 |
| 0-19 YEARS | 2,492 | 347 | 2,119 | 26 |
| 20-39 YEARS | 2,617 | 506 | 2,079 | 32 |
| 40-59 YEARS | 1,018 | 157 | 844 | 17 |
| 60+ YEARS | 551 | 25 | 516 | 10 |
| UNKNOWN | 35 | 8 | 25 | 2 |

Print Report? (Y/N): Y
Report has been printed
Generate another report? (Y/N): ___

As can be seen by the above example, attaching a user-friendly front-end to CENTS 4 could greatly enhance its ease of use. Attaching a user-friendly front end to CONCOR would also increase CONCOR's ease of use. However, designing a user-friendly front end for a data editing and correction package is a much more complex procedure. No attempt will be made to describe a possible CONCOR interface here.

There are many advantages to adding a user-friendly front-end to existing ISPC software. Using the interactive capabilities of microcomputers, the system could speed up the software development process by catching errors in the user commands as they are entered and allowing reentry of commands. This compares with the traditional method of submitting user commands in a batch job and then waiting for the job to finish before mistakes can be detected. By prompting the user for information, complex syntax requirements of command languages can usually be avoided. Prompting for information simplifies the user's development work and therefore increases productivity. Software that is easy to use makes the training process also easier. Non-programmers could work productively without an inordinate amount of training.

Adding a user-friendly front-end to existing ISPC software would be more expensive than the direct download approach. A considerable amount of time would be required to design and implement the user-friendly front-end. The user's manual would need to be modified to reflect the new command language. New training materials would need to be developed for the new user interface. In order to take advantage of the interactive capabilities of microcomputers, development costs would be unavoidable.

### 18.3.2.3 Complete Rewrite of Existing Packages

A complete rewrite of existing ISPC software is another approach to implementing statistical software on microcomputers. ISPC's statistical software is written in COBOL, which is not a popular language for software development on microcomputers. This lack of popularity may indicate either inadequacies in existing COBOL compilers for microcomputers, or difficulties in using COBOL to take advantage of the screen-oriented features of microcomputers. A complete rewrite of the existing ISPC software may be necessary to take advantage of the capabilities of microcomputer hardware and compilers.

There are two issues which must be addressed in a rewrite of the existing ISPC software. These issues are:

-- Should the systems be interpretive or generative?

-- In what language should the system be implemented?

There is a definite tradeoff between implementing a software package as interpretive versus as a program generator. Interpretive systems read the user commands and process data files directly. Generative systems, as their name indicates, generate programs which require compile and link steps before data files can be processed, but the generated programs process the data files more efficiently than interpretive systems since the generated code is customized for the specific application, and this results in less overhead. If input file sizes are small, processing is relatively simple and only one production run of the program is required, interpretive systems will run faster than generative systems. If input file sizes are large or processing is complex, generative systems will run much faster than interpretive systems. If microcomputers will only be used for processing small data files, then the system should be interpretive. If not, the system should be implemented as generative.

Selection of a programming language in which to implement software is important. The implementing language should be standardized and portable. It should allow the code to be written in a structured and modular fashion. The code should be easy to read. When executed, the code should be efficient. Each language processor examined poses certain problems.

COBOL is usually implemented on microcomputers as a pseudo-compiler. Code generated by a true compiler is more efficient than a pseudo-compiler. The ANS COBOL features of the language do not allow the user to take full advantage of the screen capabilities of microcomputers. Some vendors offer add-on packages that simplify the use of the screen display, but these add-ons are neither very portable nor standard.

Pascal is a very popular microcomputer programming language. Versions of Pascal exist on all popular microprocessors on the market today. It is highly structured and modular in design, but

is weak in its file handling ability. Also there is more than one standard for the language. The popular UCSD version of Pascal is a pseudo-compiler but is extremely portable, being implemented on most microprocessor chips.

FORTRAN is a standardized language usually implemented on microcomputers as a compiler. Unfortuanately, FORTRAN does not facilitate writing structured, modular programs and FORTRAN programs are often difficult to read. FORTRAN I/O processing is relatively inefficient compared to other programming languages. Also, based upon ISPC's research, some implementations of FORTRAN on microcomputers are inadequate for many relatively simple applications.

The C language is becoming popular. It is both powerful and structured. C is more permissive with regard to variable typing than is Pascal. Several compilers for microcomputers and minicomputers are written in C, as is a major portion of the UNIX operating system. Portability of software written in C from one UNIX system to another is excellent. Even compilers written in C can transfer among UNIX systems with relative ease. C compilers are now available under CP/M, CP/M-86, and MS-DOS. Although most C compilers are modeled on the UNIX C compiler, there is no official standard for C. The standard I/O package for C is not always the same from one operating system to another.

BASIC is the most popular microcomputer programming language. Many microcomputers come equipped with BASIC. Until recently, BASIC did not even have a proposed standard; therefore programs written in BASIC on existing microcomputers do not easily transfer to different systems. BASIC is also not very structured or modular, and most versions of BASIC are implemented as interpreters.

Currently, there is no ideal language for implementing ISPC software on microcomputers. If portability were not absolutely critical, C would be the best language as demonstrated by its acceptance for implementing operating systems and compilers. If portability were critical, the best implementing language would be the UCSD version of Pascal since it is available on a wide variety of microcomputers.

There are several disadvantages that accompany a complete rewrite. The most obvious disadvantage is the added time and cost required to design, code, test, and document the new system. Users would need to be retrained in use of the new software. It is also difficult at this time to make an adequate prediction of the future thrust of microcomputer software. New compilers such as the Department of Defense's Ada compiler and software may evolve, rendering existing software obselete. The complete rewrite approach has definite merits; however, the time and cost requirements for a major rewrite are high.

## 18.4 Conclusions

All three possible implementations have their corresponding advantages and disadvantages. The direct download approach is the easiest and least expensive, but fails to take advantage of the user-friendly capabilities of microcomputers. The complete rewrite approach is expensive and time consuming. Probably the approach of adding-on a user-friendly front-end to existing software is the best solution. It offers a compromise in cost and time requirements while offering a user-friendly interface that allows the software to take advantage of the interactive features of microcomputers.

In final analysis, whatever approach is chosen it is clear that at present there is not the kind of specialized editing and tabulating packages available for microcomputers which ISPC has developed for very large statistical data file processing in developing countries. No microcomputer software developers are addressing this specialized need (which is not surprising since no one addressed this problem on mainframes either). It is imperative that in the near future a strategy be chosen to make this kind of software available for NSO's in the developing world.

# CHAPTER 19: CONCLUSIONS AND RECOMMENDATIONS

This chapter is an attempt to summarize the material presented in previous chapters and offer recommendations on the use of microcomputers in statistical offices.

## 19.1 Assessment of the Technology

Microcomputer technology is sufficiently developed to make microcomputers a viable processing alternative for NSO's in developing countries. A number of microcomputers appear to be good candidates for the processing needs of NSO's. Eight-bit microcomputers are still the most popular hardware and have the most mature software. However, 16-bit and 32-bit machines are becoming increasingly popular. They give added addressability and speed which facilitate many statistical applications. Winchester disks are available to provide reliable secondary storage.

Development of software for microcomputers has not kept pace with hardware development. The majority of available software is oriented to 8-bit systems, although there is a considerable effort to produce software for the newer 16-bit and 32-bit microcomputers. Microcomputer software, in general, can be characterized by a great degree of user-friendliness; that is, an attempt to assist the user through menus, screens which elicit specific information from the user, and information to assist the user. For the most part, software is produced primarily for popular operating systems, such as CP/M, or for hardware with a proprietary operating system, such as Apple. The more popular software packages are available under multiple operating systems. Software packages which are written for widely distributed systems tend to be of higher quality because of the demands from a larger user community and the existence of a broader capital base for maintaining software.

While the number of software packages is staggering, few address the specific needs of statistical offices. The packages that are appropriate for statistical offices focus more on support activities and analysis, rather than on editing and tabulation which form the basis of much of a statistical office's data processing requirements. There is no software capable of doing editing and tabulation such as that done by ISPC's CONCOR and CENTS 4 packages on mainframe computers.

There are many activities within an NSO which could be done effectively on microcomputers. Among these are data entry with the possibility of concurrent interactive editing; computerization of administrative data bases; statistical analysis, particularly of summary level data; word processing; and planning which makes use of spreadsheet capability and graphics. These activities encompass a wide range of applications, including surveys of moderate size and even censuses of small areas. For the most part, NSO's will use microcomputers as general-purpose machines to perform several functions.

Microcomputer technology is not sufficiently advanced to recommend processing large-scale censuses or surveys exclusively on microcomputers. This is not to say that they are incapable of such processing, but rather that they cannot be considered equivalent to most mainframe computers for this purpose. Peripheral devices generally associated with microcomputers do not include the tape drives, high-speed printers, and large mass storage devices typically needed for large-scale processing. The absence of software for editing and tabulation such as that needed for a population census is a further problem. These deficiencies are rapidly diminishing, and it is conceivable that within 5 to 10 years microcomputer hardware and software will be capable of meeting these large-scale processing needs.

## 19.2 Current Use of Microcomputers in Developing Countries

A survey of microcomputer users revealed a considerable amount of microcomputer activity in developing countries. Apple microcomputers, followed by Radio Shack TRS-80 microcomputers, were predominant. Other vendors with moderate represent tion included Hewlett-Packard, Altos, Northstar, and Commodore. The recent announcement by IBM to market their Personal Computer internationally will undoubtedly shift the vendor representation in developing countries.

Microcomputers are being used successfully to process surveys and censuses in small areas, such as island nations. More ambitious census processing on microcomputers is being attempted, but has not been completed.

The use of microcomputers in developing countries is not without problems. Considerable frustration and idle microcomputer systems have resulted from hardware and software problems and inadequate training and support. The two biggest problems for developing countries attempting to use microcomputers are power supply and maintenance.

## 19.3 System Selection and Procurement

The decision to buy a microcomputer and the choice of hardware and software should be guided by one or more persons knowledgeable of the technology. If such a person cannot be located within an NSO, a consultant should be hired to aid in the decision-making process.

The correct approach to system choice includes identifying the tasks to be accomplished, software needs, and hardware requirements, and then finding a system that meets as many of the needs and requirements as possible. Other factors to be considered include such things as local vendor representation, experience with microcomputers already installed in the country, cost, and delivery time. Technical details such as appropriate voltage and number of cycles, as well as the requirement for power protection, need to be addressed.

Some degree of customization, or user-specific configuration, of a microcomputer system will often be necessary. The survey of microcomputer users showed that the vendor's basic system frequently fails to meet all the user's needs. The user may require a printer with special characteristics, an additional board to increase the number of characters displayed on the monitor screen, a numeric keypad, or something considerably more complex such as a tape drive. The new user may opt to purchase the basic system and through its use decide what should be added or upgraded. In any case, a user should consider system customization only under the following conditions: the user can identify at least one case where someone has actually done what the user plans to do, and the user has a local source of assistance if problems arise.

The NSO should formulate an overall plan for procurement of microcomputer systems, as opposed to allowing <u>ad hoc</u> acquisition which has the potential for incompatibility. This will not necessarily dictate a particular brand of hardware, but perhaps compatible operating systems or simply communications capability among equipment obtained. If mainframe-microcomputer communication is desired, it may be necessary to upgrade the mainframe computer in order to support communication.

Procurement and customs regulations should be studied in order to expedite the process of obtaining microcomputer systems. These can vary greatly from one country to another.

Developing countries should buy only fully integrated hardware and software. The hardware should be "burned in" for a minimum of 72 hours. The burn-in period will often catch faulty hardware before it is sent out for installation. Many problems can be avoided by obtaining the hardware and software from the same source. The responsibility for problem resolution is less ambiguous when only a single vendor is involved.

## 19.4 <u>Support</u>

Training in the proper use of hardware and software and in trouble-shooting is extremely important. It should include the chance for each user to do exercises on a microcomputer which reinforce the material covered.

Ongoing user support is necessary to answer the many questions that arise as users become familiar with microcomputer systems and as problems arise. It must be provided by someone who is knowledgeable of both the hardware and the software involved.

Consideration must be given to maintenance. Unfortunately, it does not become important until a breakdown occurs. Redundancy of hardware provides considerable protection, no matter which maintenance route is taken. Local maintenance is, of course, preferred to having to send components away for repair. If maintenance cannot be obtained from a local firm, NSO employees can be trained to perform a degree of maintenance by swapping boards and chips.

A central or regional support group, sponsored by an international agency such as AID, could be extremely effective in providing support on many levels. These include giving central, regional, or local training; providing current information on microcomputer technology to developing countries; participating in needs assessments and system selection and procurement for individual countries; and providing trouble-shooting advice. Such a group would have to include highly-trained technicians with a knowledge of diverse microcomputer hardware systems and software packages. Furthermore, these persons would need a first-hand knowledge of providing technical assistance to developing countries.

## 19.5 Use of the Microcomputer System(s)

A microcomputer can probably best be used in combination with other computing equipment, in order to allow the access to additional resources. These might include things like faster line printers or the greater storage capacity commonly found on mainframe computers and minicomputers. This observation is based on reponse from the user survey which showed that for many applications it is desirable to be able to transfer data from one microcomputer to another or to a mainframe computer for further processing. This allows the microcomputer to be dedicated to a specific task, such as data entry or analysis, instead of forcing it to be a general-purpose machine.

The use of microcomputers in combination with other computing equipment implies the need for a communications capability which can be achieved in a number of ways. The use of a local area network to connect microcomputers is quite versatile and minimizes system degradation. It has the further advantage of not having to depend on the telephone lines, which are often unreliable. Communication with other computers can be achieved through telecommunication, hardwiring, or use of a magnetic medium for file transfer. Some computers, such as older mainframe computers, require modification to support communications.

Any task proposed for a microcomputer should be carefully thought out. A system run on a mainframe might need to be redesigned to take into consideration the strengths and weaknesses of the microcomputer. For example, time-consuming processes, such as sorting data files, could possibly be avoided by using different data structures and access methods.

The size and cost of microcomputers, as well as their claims to user-friendliness, attract users who formerly had programmers do their work on mainframe computers. These people generally utilize packaged software to manipulate data files, create budgets, query data bases, or perform statistical analysis.

Custom program development is often necessary to augment the capabilities provided by packaged software. The compilers and interpreters are still somewhat unreliable and poorly documented, for the most part. Furthermore, it is often much more difficult to work with a data file using various language processors or software

packages on a microcomputer as opposed to doing the same thing on a mainframe computer. Where adequate packaged software exists, it is undoubtedly more cost-effective to use it instead of attempting to write equivalent software.

## 19.6 Impact on the National Statistical Office

Although the cost of microcomputers is low, the NSO may not realize a cost savings by their introduction because there may be widespread demand for microcomputer systems within the NSO, extending into areas that previously made no use of computing. Furthermore, there will probably be the need to maintain mainframe capability for at least a transition period, if not indefinitely.

Microcomputers have the potential to provide more timely statistics of higher quality. It is difficult to quantify this potential improvement. Factors such as the ability to edit data at their source (as opposed to automatically imputing values without regard to recorded responses), the possibility of decentralizing data preparation to avoid a backlog in a central office, and the idea of giving policymakers access to data through their own desktop computers and graphics capability contribute to this added potential.

Persons at various levels of the NSO who formerly had limited or no connection to mainframe computer activity will be significantly affected by the introduction of microcomputers. Microcomputers may, in fact, change the description of some positions and create the need for others.

Microcomputers have the potential to ameliorate two problems which pervade NSO's. The rapid turnover of scarce data processing staff may not have as serious an effect on the overall progress of computing as more permanent personnel can assume at least some processing responsibility. The introduction of microcomputers will likely reduce the demand on generally overburdened mainframe computers for small-scale manipulation of data.

## 19.7 Considerations for Developing Countries

Local vendor representation can be extremely important to maintenance and other support. It may be advisable to compromise on some system requirements in order to obtain hardware which can be supported locally.

Redundancy of equipment provides the capability to continue processing if one system fails. If timing is at all critical, complete system redundancy is recommended.

Power supply problems can have extremely serious consequences for program and data files, as well as for system components. An Uninterruptable Power Suoply (UPS) should be purchased for any system operating in a questionable power supply environment.

If local resources are not available for training and ongoing support, a means for supplying this must be identified. This may entail retaining a c nsultant in the country of origin of the microcomputer system in the worst case), hiring a local expert, or sending staff to cour:es. Without proper training and ongoing support, the introduction of microcomputers will be severely limited or may fail altogether.

## 19.8 The Future

Microcomputer technology is changing so rapidly with so many possible alternative directions that it is difficult to predict what course languages, operating systems, microprocessors, and software packages will take. It can be said with certainty that microcomputers will continue to become more powerful and more affordable. The technology is destined to touch everyone's life.

The situation for developing countries will only improve. Existing shortcomings in vendor representation, statistical software capability, peripheral speed, and storage will eventually disappear. The introduction of microcomputers in NSO's of developing countries is inevitable; a rational and educated use of these new tools can have a far-reaching, positive impact.

# APPENDIX: CHRONOLOGY OF PROJECT IMPLEMENTATION

The preceding text describes many facets of the feasibility study, but does not give the reader a thorough understanding of how the project was implemented. The appendix is included to provide a chronology of the activities that were undertaken and the events that took place during the course of the project.

6/81 We were becoming increasingly aware of interest in microcomputers on the part of donor agencies, as well as among our counterparts in developing country national statistical offices (NSO's). We submitted to the Office of the Science Advisor of the Agency for International Development (AID) a proposal to perform a research project which would study the feasibility of introducing microcomputers in developing country NSO's.

8/81 AID awarded us with a research grant to conduct such a study with the following major objectives:

-- To study microcomputing technology in order to assess the capabilities of existing hardware and software, understand the microcomputer marketing approach, and learn of trends for the future.

-- To assess the current and likely future availability of microcomputers, microcomputer software, and associated support in developing countries.

-- To acquire one or more microcomputers with the intention of doing processing typical of that of a national statistical office.

-- To explore the limitations of microcomputer technology and potential problems for the microcomputer user in a developing country.

-- To present guidelines for the selection, institutionalization, and use of microcomputers in developing countries.

10/81 The project commenced with the start of the new fiscal year. A 3-person team was chosen to implement the study over an 18-month period. Our first goal was to learn as much as we could about the past, present, and future of microcomputer technology. This involved extensive reading and discussions with persons knowledgeable of the technology.

1/82 As the number of personal discussions and meetings increased and correspondence grew in volume, we sensed the need for an orderly means of recording these contacts. A file was developed to capture the name, address, telephone number, date, summary, and other pertinent information for each contact made. Each entry was also assigned one or more keywords to allow for easy extraction of a subset of entries. This interactive system was developed on a mainframe computer, as we had not yet obtained a microcomputer.

1/82 To give us a focal point, we decided to create a scenario depicting the current situation in a typical developing country NSO in terms of existing hardware, software, physical environment, staffing, mode of operation, applications, and typical problems to be resolved. This description was based on our files on developing country computer centers and on personal experience. The resulting documentation set the framework for subsequent tasks in the study.

2/82 This seemed like a good time to document what we had learned thus far in the study in our transition from mainframe computing to microcomputing. We wrote a paper entitled "Initial Thoughts and Findings" which conveyed information on three areas of investigation: a description of the existing data processing situation in a developing country NSO, a description of microcomputers with an emphasis on how they compare to mainframe computers, and a summary of three microcomputer applications in developing countries.

3/82 As we looked ahead toward procuring microcomputer hardware and software, we felt the need to hire a consultant to advise us on critical matters. After interviewing a number of potential candidates, we selected someone with many years of data processing experience and a strong microcomputer background.

4/82 We decided to obtain two microcomputer systems, one representative of the state-of-the-art in technology and the other typical of what is currently found in developing countries. We defined a set of desirable characteristics for each of these systems that would serve as the basis for choosing specific hardware and software. We listed applications to be implemented on each system

4/82 An important part of our information-gathering activities involved mailing out questionnaires to microcomputer users and vendors. The three questionnaires focused on the following variables:

<u>User Questionnaire</u>

Goals in obtaining microcomputer
Year system obtained
Funding source
Cost
Where and how system obtained
System design approach
System name
Memory size
System configuration
Physical environment
Performance
Operating system
Documentation
User environment
Mode of operation
Mainframe computer interface

Vendor representation
Maintenance
Training
User support
Software
Applications
Operating schedule
Memory, speed, and power supply problems
Security
Strengths and weaknesses
Potential use

Hardware Questionnaire

Vendor background
Hardware systems
International representation
Future systems
Support
Training
Documentation
For one or more representative systems:
- System name
- List price
- Characteristics
- Delivery time
- Microprocessor
- Bus
- Memory
- Operating systems
- Software
- Peripherals
- Networking capabilities
- Telecommunications features
- Environmental requirements
- Electrical requirements
- Intended applications

Software Questionnaire

Type of software
- Operating systems
- Language processors
- Utilities
- Statistical analysis software
- Tabulating/reporting software
- Graphics software
- Data base management software

Support
Documentation
Training
Vendor background
International representation
Future plans

The initial mailout included 152 known users, 203 possible users at NSO's, 164 hardware vendors, and 131 software vendors.

4/82 It was becoming apparent to us that microcomputers offered new possibilities for data entry with concurrent editing. We organized a seminar to explore this application as well as to discuss other microcomputer issues with a variety of experts. Among these were survey statisticians, Computer-Assisted Telephone Interviewing (CATI) experts, our consultant, and a representative from the U.N. Statistical Office. The seminar pointed out both strengths and weaknesses of this approach to data entry as we considered three increasingly comprehensive scenarios of implementation.

4/82-5/82 In the process of deciding which microcomputers to procure, we attended numerous demonstrations of hardware and software. In addition, we ran the benchmark programs published in BYTE magazine to gain information on speed.

6/82 One team member designed a system for cataloguing the information we were acquiring through our reading in order to allow us to retrieve it easily at a later date. The system captures key information on "incidentals," such as name and date of publication, page number, and description. A hierarchical list of keyword acronyms was developed to provide identifiers for selecting particular entries. (The system was later implemented on the CompuPro microcomputer using dBASE II).

6/82 We developed a preliminary outline of the final study report which you are reading. Each topic was followed by a list of references which continued to grow over the months that followed.

6/82 We reached a decision on hardware and software for the two microcomputer systems to be procured. A Godbout CompuPro system was selected as the larger system; an Apple II+ was chosen as the smaller system. The reader is referred to the specific chapters on these two microcomputer systems for more details on system selection, characteristics, procurement, installation, and applications.

7/82 After 9 months of work we had accumulated a large number of reports, books, and periodicals. These materials were organized and catalogued in a lending library to control their circulation. The books and periodicals procured included the following:

Books (with author, publisher, and date indicated)

The CP/M Handbook with MP/M by Rodnay Zaks, Sybex, 1980
Datapro Directory of Microcomputer Software, Datapro, 1982
Datapro Directory of Small Computers, Datapro, 1983
A Directory of Computer Software Applications, NTIS
From Chips to Systems by Rodnay Zaks, Sybex, 1981
International Microcomputer Dictionary, Sybex, 1981
Introduction to Pascal by Rodnay Zaks, Sybex, 1981
Microcomputer Dictionary and Guide by Charles J. Sippl, Matrix Publishers, 1975

Microcomputer Management and Programming by Carol Anne Ogdin, Prentice Hall, 1980
Microprocessor Operating Systems by John Zarrella, Microcomputer Applications, 1981
Microprocessor Interfacing Techniques by Rodney Zaks, Sybex, 1979
Mindstorms by Seymour Papert, Basic Books, Inc., 1980

<u>Periodicals</u> (with frequency and vendor address indicated)

Business Computer Systems, Monthly,
270 St. Paul St., Denver, CO 80206
BYTE, Monthly,
Byte Subscriber Service, P.O. Box 328, Hancock, NH 03449
The Computerist's Directory, Semi-Annually,
Alternet, Inc., 15250 River Rd. Suite B, Guerneville, CA 95446
Computerworld, Weekly,
Box 880, 375 Cochituate Road, Framingham, Mass. 01701
Creative Computing, Monthly,
P.O. Box 5214, Boulder, CO 80321
Datamation, Monthly,
875 Third Avenue, New York, NY 10022
Desktop Computing, Monthly,
P.O. Box 917, Farmingdale, NY 11737
Dr. Dobb's Journal, Monthly,
1263 El Camino Real, Menlo Park, CA 94025
EDN, Monthly,
P.O. Box 5262, Denver, CO 80217
Information Systems News, Weekly,
111 East Shore Road, Manhasset, NY 11030
Infosystems, Monthly,
Hitchcock Publishing Company, P.O. Box 3007, Wheaton, Il 60189
Infoworld, Weekly,
375 Cochituate Road, Box 880, Framingham, Mass. 01701
Microcomputing, Monthly,
P.O. Box 997, Farmingdale, NY 11737
Mini-Micro Systems, Monthly,
270 St. Paul Street, Denver, CO 80206
PC, Monthly,
1528 Irving St., San Francisco, CA 94122
Small Systems World, Monthly,
330 S. Wells, Suite 1304, Chicago, IL 60606
Softalk, Monthly,
11021 Magnolia Boulevard, North Hollywood, CA 91601

7/82 Many of the questionnaires mailed out in April had been completed and returned. In addition to the questionnaire mailout to vendors, a letter simply requesting literature on their products had been widely distributed to hardware and software vendors. These efforts had produced responses from 125 microcomputer users, 275 hardware vendors, and 325 software vendors. The materials were all indexed, filed, and entered in a database for easy reference.

8/82 We began to contemplate writing this document and a preliminary assignment of topics was made to the team members based on their areas of expertise and interest.

8/82 The contract for the CompuPro hardware was awarded to one vendor; the CompuPro software contract was awarded to a different vendor. The involvement of two vendors proved to be a problem (described in the chapter which discusses the CompuPro).

9/82 The contract for Apple II+ hardware and software was awarded.

10/82 The CompuPro and Apple hardware and software were delivered. A team member integrated the Apple II+ hardware. The reader is referred to the chapter which presents our experience with the Apple for a discussion of the problems encountered in system integration. Additional CompuPro hardware and software were ordered.

10/82-11/82 Team members installed the software, making modifications where necessary, and became familiar with both hardware and software.

10/82 Our consultant provided training for staff members in the CP/M operating system and WordStar and SuperCalc software packages.

11/82 The second CompuPro hardware and software contracts were both awarded to the same vendor.

11/82-2/83 We implemented a number of applications on each microcomputer system, based on the plan developed in April. These applications were chosen because they were representative of the work done in developing country NSO's.

1/83 The additional CompuPro hardware and software were delivered, providing a hard disk among other things.

1/83-5/83 We produced a draft of this document, following the outline developed earlier in the study. Extensive research was necessary to write many of the chapters. The user questionnaires and the incidentals data base proved to be invaluable resources.

6/83-8/83 The draft was reviewed by numerous people and their comments were submitted for incorporation.

9/83 We modified the draft document in accordance with the comments received.

10/83 The document was published and subsequently distributed.

# G L O S S A R Y

This glossary includes technical terms used within the text of this document. It has been compiled from the following sources:

Creative Computing, March 1983

Desktop Computing, September 1982

From Chips to Systems by Rodnay Zaks, 1981

Infoworld, April 25, May 2, July 11, July 18, July 25, 1983

McGraw Hill Dictionary of Scientific and Technical Terms, 1978

Microcomputer Dictionary and Guide by Charles J. Sippl and David A. Kidd, 1975

Microcomputer Management and Programming by Carol Anne Ogdin, 1980

Mini-Micro Systems, August 1982

Onyx Systems, Inc. brochure, March 1983

Popular Computing, December 1981

ACOUSTIC COUPLER: A device to get digital data into and out of the telephone network, using sound waves. This is accomplished by attaching a telephone handset to the acoustic coupler that transmits tones representing the outgoing data into the handset's mouthpiece and receives tones representing incoming data from the handset's earpiece.

ADDRESS: In a computer, a number that serves as a pointer to a location in storage. If the computer's storage is thought of as a collection of cubbyholes, the address is the pointer that allows the computer to find a particular box.

ADDRESS BUS: The part of the computer that carries the information about what storage location is expected to supply or receive data during the current processing step. Physically, it is usually a group of wires or printed circuit conductors and plugs, along with transmitters, buffers and receivers that send, reinforce and capture the information, respectively.

ADJUSTABLE HOUSING: An ergonomically designed enclosure for a hardware component, usually a monitor, that allows the component to tilt, swivel, or in some way adjust for the user's comfort. See ERGONOMICS.

ALU: Arithmetic Logic Unit. One of the basic units of a computer's CPU (Central Processing Unit) containing the circuitry for arithmetic operations. See CENTRAL PROCESSING UNIT.

APPLE JUICE : A power conditioner and battery backup for Apple computers.

ASCII CHARACTERS: An acronym for American Standard Code for Information Interchange, the common name for the most widely used method of encoding characters into codes made up of groups of bits. Virtually all minicomputers and microcomputers operate internally using ASCII, as do mainframes not made by IBM. The ASCII code is made up of 32 control characters that do not have a printable image and 96 printable characters that are often referred to as graphic characters.

ASSEMBLER: A program that translates computer instructions written in a particular form suitable for reading by humans to a form suitable for execution by a computer. The input data is called an assembly-language program, and the output is a binary or object program (or sometimes an intermediate step that must be further translated to machine code).

ASYNCHRONOUS COMMUNICATION: A way of sending characters between parts of a system in which no timing is kept between individual characters. Characters are either sent as available or when both sending and receiving systems say they are ready.

AUTO-REPEAT: A feature of a terminal keyboard where a key held in a depressed position repeatedly transmits that character to the system.

AUTOMATA : Apparatuses with concealed mechanisms that enable them to move or work by themselves.

AUTOMATED CALENDARS: Calendars which are maintained and updated on computers.

AUTOMATIC ANSWERBACK (Auto Answer): A feature of data-processing and transmission systems by which these systems can receive calls on the telephone network and handle the chores of ring detection, answer, and handshaking (starting off the data exchange) without human intervention.

AUTOMATIC OUTBOUND DIALING (Auto Dial): A feature of computer systems or modems (the part that connects a computer or terminal to a phone line) to dial phone numbers under computer control. More advanced systems wait for dial tones, detect busy signals and report successful call completion.

BASEBAND TECHNOLOGY: A local area network transmission scheme that generally involves a single high-speed digital signal being sent over a wire or cable medium. Time-division multiplexing permits baseband networks to carry multiple signals.

BASIC: Beginner's All-purpose Instruction Code. A common high-level time-sharing computer programming language. It is easily learned and used for direct communication between teletype units and remotely located computer centers. The language is similar to FORTRAN II and was developed by Dartmouth College for a General Electric 225 computer system.

BASIC INPUT/OUTPUT SYSTEM (BIOS): The part of an operating system which must be modified to reflect a particular hardware configuration.

BATCH MODE: A specific method of processing in which a number of similar input items are grouped for processing during the same machine run.

BAUD RATES: A type of measurement of data flow in which the number of signal elements per second is based on the duration of the shortest element. When each element carries one bit, the Baud rate is numerically equal to bits per second (bps).

BENCHMARK ROUTINE: A set of routines or problems which will help determine the performance of a given piece of equipment.

BIOS: See BASIC INPUT/OUTPUT SYSTEM.

BOARD: An electrical panel which can be changed with the addition or deletion of external wiring.

BOARD SWAPPING: A maintenance technique, whereby an entire board is replaced by a new board in order to resolve a problem.

BOOTSTRAP: A piece of software, usually stored permanently in memory, that activates other pieces of software in order to bring the computer from "off" into readiness for use.

BROADBAND TECHNOLOGY: A local area network transmission scheme that permits the sending of multiple signals simultaneously over a single medium. A broadband can conceivably carry video, voice, and data signals simultaneously, using a technique that involves frequency-division multiplexing.

BUBBLE MEMORY: A computer memory in which the presence or absence of a magnetic bubble in a localized region of a thin magnetic film designates a 1 or 0; storage capacity can be well over 1 megabit per cubic inch.

BURN IN: To operate continually over an extended period of time in order to prove in hardware components.

BUS: One or more conductors used as a path over which information is transmitted.

BYTE: A group of eight bits used to encode a single letter, number, or symbol.

C: A medium- to high-level programming language developed at Bell Telephone Laboratories.

CENTRAL PROCESSING UNIT (CPU): The logic and arithmetic circuitry inside a computer. The place where data actually get processed.

CENTRONICS INTERFACE: One of several standard protocols (including the design of cable, plug, and circuitry) for connecting a peripheral device such as a printer to a microcomputer. The Centronics interface transmits data in parallel.

CHAINING: Chaining is a feature of some high-level language compilers that enables one computer program to prompt the execution of another program as it ends. Chaining makes possible the development of large programs consisting of several small program modules. The smaller modules are linked together as if in a chain. Like the use of overlays, chaining extends the capability of systems with limited memory.

CHASSIS ASSEMBLY: The optional chassis assembly in many systems mounts in a standard track and provides convenient mounting locations for the processor, power supply, and peripheral interface cards. The chassis assembly is often designed using a printed circuit backplane for all interconnecting wiring.

CHECK DIGIT: A character or digit added to a sequence of characters or digits that helps detect any errors in the sequence. The check characters are generated by applying a known set of rules to the character sequence, and the program circuit receiving the data can check whether they compute the same check value they receive. If not, the data are presumed to be in error.

CHIP: The actual piece of semi-conductor material on which integrated circuits are made. More formally: a wafer of semiconductor material is processed and then broken up into dice. Each die or chip is then packed or mounted on a carrier of some type of use.

CHIP-SWAPPING: A maintenance technique, whereby individual chips are replaced by new chips in order to resolve a problem.

CIRCUIT BOARD: A card or board usually constructed of laminate or resinous material to which the circuitry of a device such as a microcomputer is attached. The board is usually covered with copper and then parts are etched away to leave the appropriate electrical connections.

CLAMPING VOLTAGE: The acceptable range of voltage. Line conditioners will usually allow incoming voltage within an acceptable range.

CLOCK: The most basic source of synchronizing signals in most electronic equipment, especially computers.

CODASYL: An acronym for Conference on Data Systems and Languages, a computer-industry organization set up by the U.S. Department of Defense in the late 50s. Its most famous product is the language COBOL, but it also developed a set of standards for data-base structures that is used with other languages as well.

COLOR MONITOR: Essentially a color television set without a tuner or an antenna; a color television set can be used as a color monitor.

COMMAND LANGUAGE: Several data base management software packages have sets of instructions (including commands such as sort, list, display, etc.) that may be used with logical operators (such as if-then, and, or, etc.). This relatively complete language, resembling a high-level language, is called a command language.

COMMON SERVER: The central node of a networked system.

COMMUNICATION POINT: An end-point for communications; the origin or destination for data or other files transmitted.

COMMUNICATIONS LINK: The means of connecting one location to another for the purpose of transmitting and receiving information.

COMPATIBLE: Refers to computer programs and accessory equipment that is claimed to operate correctly with a particular (other) brand or type of equipment. For example, "IBM PC compatible" equipment is supposed to operate correctly with IBM Corporation's Personal Computer.

COMPILER: A computer program that translates instructions written in a specific high-level programming language into machine language the computer can understand. If the program is in COBOL, a COBOL compiler is needed to translate.

COMPILER/INTERPRETER: Refers to language processors that combine features of both compilers and interpreters. Usually these processors translate the source code into an intermediate code which is not the native microprocessor code for that computer system. This intermediate code requires a special processor called a "runtime" processor to interpret the intermediate code at program execution time. See NATIVE MICROPROCESSOR CODE.

COMPONENT: One of the essential functional parts of a subsystem or equipment, possibly a self-contained element or a combination of parts, assemblies, attachments, or accessories.

COMPUTATIONAL FORMAT: Written in COBOL language, numbers may be stored in a variety of formats. Some are kept in a form that ressembles the number codes used by printers and keyboards. Others may be stored as actual binary values that are used for fast arithmetic and logical operations. The latter format is referred to as a computational format.

CONFIGURATION: The design or layout of a particular computer system with all its peripherals. To configure a system is to design a system to meet specific needs.

CONSTANT VOLTAGE TRANSFORMER: A transformer designed to provide a constant voltage as output despite fluctuations in its supply of electricity.

CONTINUOUS VARIABLE: In mathematics, variables may be categorized as either discrete or continuous. Discrete variables have a set of values that is discrete, consisting of distinct identifiable members. For example, sex would be considered a discrete variable with two possible values, male and female. A continuous variable would not have a distinct set of values but rather a continuum of values over a given range. The weight of a child could be a continuous variable since weight recording could be made to any desired degree of accuracy, making the set of values for the variable a continuum of values from 1.000kg to 10.000kg, for example.

CONTROL PROGRAM FOR MICROCOMPUTERS (CP/M): A popular operating system for 8-bit microcomputers.

CONTROLLER: A hardware device used to control the mechanical operation of a peripheral. The device sends signals such as read, write, interrupt, reset, and various types of acknowledgements to a peripheral device. The controller device also receives and sends signals to the CPU. Controllers relieve the processor of device control responsibilities.

CONVERSION: Modification of an existing program or system to allow it to run under a different language processor or operating system.

COUNTER: A register or storage location used to represent the number of occurrances of an event.

CP/M: See CONTROL PROGRAM FOR MICROCOMPUTERS.

CPU: See CENTRAL PROCESSING UNIT.

CROSS-TABULATION: Two-dimensional presentation of data in tabular form, whereby one or more variables define the columns and one or more variables define the rows.

CRT: Cathode Ray Tube. The video tube in a computer terminal. Often used to refer to the terminal itself.

CURSOR: Refers to various position indicators frequently employed in a display on a video terminal to indicate a character to be corrected or a position in which data is to be entered.

CURSOR ADDRESSING: In a CRT terminal with 24 lines and 80 characters per line there are 24 X 80 character positions on the screen. The CRT's cursor, or marker, may be directed to any of the positions if the CRT terminal is equipped with the circuitry necessary to interpret instructions which control cursor placement. Cursor addressing makes it possible to place text at the bottom of the screen without writing over text that appears at the top.

CUSTOMIZATION: Adaptation to a particular environment or to accomodate particular hardware or software components.

DAISY WHEEL: A wheel-like print head used on some types of printers to print typewriter quality characters.

DATA BASE: An organized collection of data.

DATA BASE MANAGEMENT: The control, maintenance, and modification of a data base.

DATA BUS: Most microprocessors communicate externally through the use of a data bus. Most are bidirectional, e.g., capable of transferring data to and from the CPU, storage, and peripheral devices.

DATA ENTRY STATION: A unit which allows one operator to perform data entry.

DATE AND TIME STAMPING: When an operating system stores a file on a disk, some record of the file's location and name must be stored on the disk as well to make retrieval of the file possible. Some operating systems store information on the time of day and date at the time the file is stored. This time and date stamping can be very useful in more precisely identifying a file.

DECENTRALIZED DATA PROCESSING: The housing and handling of data by individual subdivisions of an organization or at each geographical location of the parts of an organization.

DIAGNOSTIC MESSAGE: Both compilers and operating systems generally provide software to help the computer user understand what has gone wrong when an error has occurred in the execution of a program. The messages generated by this software are called diagnostic messages.

DIRECT MEMORY ACCESS: Direct Memory Access, sometimes called data break, is the preferred form of data transfer for use with highspeed storage devices such as magnetic disk or tape units.

DIRTY POWER: A supply of electricity that is characterized by fluctuations of frequency or voltage or failure is referred to as "dirty" power.

DISK CONTROLLER BOARD: A printed circuit board that interfaces between a CPU and a disk storage device.

DISK DRIVE CONTROLLER: The circuitry required to make possible the use of a disk drive by the CPU of a computer.

DISKETTE: A flexible mylar disk coated with magnetic material and housed in a paper-like jacket. They have less capacity than hard disks and are much slower, but are less expensive.

DISPLAY BOARD: A controller board designed to control activities associated with generating images on a CRT.

DISTRIBUTED SYSTEMS: Refers to various arrangements of computers within an organization in which the organization's computer complex has many separate computing facilities all working in a cooperative manner, rather than the conventional single computer at a single location.

DOCUMENT SLITTER: A device which separates multiple-page questionnaires into single sheets.

DOT MATRIX PRINTING: A method of printing wherein each character is composed of an array of dots, as opposed to fully formed characters.

DOWNTIME: Any period of time when the computer is not available or not working.

DOWNLOAD: Refers to the process of copying information from a large computer system, such as a mainframe, to a smaller system, such as a microcomputer. The method of copying information is usually by communications.

DYNAMIC METAL-OXIDE SEMICONDUCTOR (MOS) CIRCUITS: Dynamic circuits use the absence or presence of charge on a capacitor to store information, typically with three or four transistors per cell. Fewer transistors give higher packing density and lower cost. Since the capacitor that stores the charge has a leakage current, the stored information degrades slowly and therefore must be refreshed (normally by simply addressing the memory periodically so that every address is covered eventually).

ELECTRONIC MAIL: A computerized mail system which eliminates the need for transmitting paper documents; instead, electronic signals are used to transfer information.

ELECTRONIC TAP CHANGER: A device used to change the ratio of the input and output voltages of a transformer over any one of a definite number of steps.

EPROM: Electrically programmable Read Only Memory (EPROM) is ideally suited for uses where fast turn-around and pattern experimentation are important. Some types are packaged in a 24-pin dual in-line (DIP) package with a transparent lid. The transparent quartz lid allows the user to expose the chip to ultraviolet light to erase the bit pattern. Therefore, unlike a metal mask Read Only Memory can be written into the EPROM devices. As supplied or erased, all data bits in EPROM are initially interpreted as zeroes (output high), with programming operation forcing zeroes to ones or leaving zeroes unchanged. Ultraviolet erasure of the EPROM restores the data to all zeroes.

ERGONOMICS: Ergonomics is the study of human capability and psychology as it relates to the working environment and equipment used in work.

EXECUTION: The final step in running a computer program, whereby program statements actually act on data and/or actually generate results.

FAST REPEAT: Refers to a feature of a terminal keyboard where a combination of holding a key in a depressed position and pressing a repeat-key results in a rapid auto-repeat transmission of that key. See AUTO-REPEAT.

FAST STORE: See PRIMARY STORAGE.

FILE AND RECORD LOCKING: File locking is a software function that prevents the use of a single file by more than one user at a time. Record locking capability may allow more than one user to access a file but not gain access to the same record at the same time.

FILE HASHING: A technique used for the random storage of files in which the address of the file is derived from the use of a random number.

FIXED-FIELD FORMAT: A format in which specific locations on a record are always associated with specific data fields.

FLOATING-POINT ARITHMETIC: A method of performing arithmetic operations in which numbers are expressed as integers multiplied by a radix raised to an integer power. Floating point arithmetic makes it possible to describe and manipulate extremely large numbers and precise decimal values using two small nteger values.

FLOPPY DISK: Another term for diskette. See DISKETTE.

FOOTPRINT: Quantity of desktop space occupied by a microcomputer.

FRAMING RATE: The speed at which an image on the CRT is refreshed. The unit of measurement is typically in megahertz (MHz).

FREQUENCY: Refers to the number of recurrences of a periodic phenomenon in a unit of time. Electrical frequency is specified as so many cycles per second. Frequency is symbolized by f.

FREQUENCY INDEPENDENT: Devices that run internally from AC (alternating current) are termed frequency dependent since they are subject to the electrical cycles (Hertz) inherent in alternating current. Devices that run internally on DC (direct current) are termed frequency independent since they are not subject to the cycles inherent in AC. Most 5-1/4" disk drives are frequency independent and most 8" disk drives are frequency dependent.

FRONT-END: A software component designed to provide input to or interface with another software component or interface with the user. The front-end may perform preprocessing translations or file handling but normally does not perform program execution.

FULL-SCREEN EDITING CAPABILITY: In contrast to line oriented text editors that require all modifications to a file of text to be performed on a line-by-line basis, full-screen editors display the file of text with as many as 24 lines on the CRT at one time and allow modification of the file to be accomplished by merely positioning the CRT cursor over the text that is to be changed.

GATEWAY: A connecting device that acts as an interface between two separate local-area networks, or between a local-area network and another communication device.

GIGABYTE: One billion bytes.

GLOBAL CHANGE: A feature of text editors that allows mass changes of an occurrence of a text string over a series of lines.

GRAPHICS PRINTING: The ability to print specific graphics characters in addition to text. An increasingly necessary printer feature.

GROSCH'S LAW: A justification for centralized computing on the economies of scale, stating that computing power varies as the square of the cost of the hardware.

HANDSHAKING: The establishment of synchronization between sending and receiving equipment by means of exchange of specific character configurations.

HIERARCHICAL FILE: A file with multiple record types related to one another in the manner of grandfather-father-son, etc. For example, a file of records for a household survey is often designed as a hierarchical file with each household record serving as the "father" of a number of records on individuals in the household.

HIGH-RESOLUTION GRAPHICS: Refers to the detail with which graphics can be represented. The definition of high-resolution is relative. High-resolution graphics on the Apple II+ is 280 by 192 pixels. High-resolution graphics on 16-bit microcomputers tends to be higher, usually somewhere around 600 by 400 pixels. See PIXEL.

HOME: Refers to either a key on a terminal keyboard or a command in a program language that clears the screen and sets the cursor to the top left-hand corner of the screen or text window.

HOST: The primary or controlling computer in a multiple computer operation.

IEEE-448 STANDARD: A standard which provides for the transfer of 16 bits of data in parallel; sometimes called the General Purpose Interface Bus (GPIB).

IMPACT PRINT: When print is obtained by the impact of a striker through a ribbon. This category includes fully formed character printers as well as many dot matrix printers.

IMPUTATION: The process of assigning a value to a data field which is either blank or otherwise incorrect.

INSTITUTIONALIZATION: The process of inroducing a new technique or new technology in an environment in which it has not been used previously.

INSTRUCTION SET: The set of instructions which a computing or data-processing system is capable of performing.

INTEGRATE: To put the various components of a microcomputer together so that they function harmoniously as a system.

INTEGRATED CIRCUIT: Also known as a chip, this is a group of interrelated circuits in a single package.

INTEL 8086: A microprocessor chip produced by Intel. It is characterized as a 16-bit chip.

INTELLIGENT INTERFACE: A peripheral controller board that can perform complex processing tasks based on instructions received on a bus. By using such an interface, the Pkaso parallel port on the Apple II+ can produce printed images from the graphics image on the CRT without requiring intervention from the Apple II+ CPU.

INTERACTIVE: A program that is able to carry on a "conversation" with the operator or interfaces to other programs. The program prompts the operator, helping him through a routine, while checking input for acceptability and notifying the operator when an error is made.

INTERFACE: The physical link connecting two devices in a computer system.

INTERFACE BOARD: The circuit board containing the necessary circuitry to connect peripheral devices to the CPU of a microcomputer. The interface board may provide plugs for any of a number of different connectors.

INTERNAL BUS: Communication lines laid down as a circuit on the chip itself.

INTERPRETER: A computer program which translates a single line of a high-level language at a time for the computer. Interpreters are more convenient but less efficient than compilers.

INTERRUPT-DRIVEN: An interruption of the normal operation of a computer program may be caused either through software or, when the microprocessor provides this capability, through the use of hardware interrupt circuitry. When the operation of one processing task can be halted while another operation is performed, the task is said to be interrupt-driven.

INVERTER: A device that changes AC to DC or vice versa. It frequently is used to change 6 volt or 12 volt direct current to 110 volt alternating current.

ISOLATION TRANSFORMER: A transformer placed within an electrical system to protect one part of the system from undesired interferences of other parts.

KB: SEE KILOBYTE.

KEYBOARD ENHANCER BOARD: A board designed to improve or correct features inherent in the standard system keyboard. For example, the Videx keyboard enhancer for the Apple II+ provides the additional features of upper and lower case, a type ahead feature, fast-repeat, and auto-repeat.

KEYCLICK SOUND: The sound that is audible when a key on the keyboard is depressed. On some keyboards, this sound may be adjusted.

KILOBYTE (KB): Term used in defining memory capacity; 1024 bytes.

LAN: See LOCAL AREA NETWORK.

LANGUAGE PROCESSOR: A term used to refer to high-level language compilers, pseudo-compilers, and interpreters.

LANGUAGE TRANSLATOR: Any assembler or compiler that accepts human-readable statements and produces equivalent outputs in a form closer to machine language.

LINE CONDITIONER: A device used to reduce amplitude and phase delays over certain frequency bands in electrical power supplies.

LINE WRAP: A feature of some CRT's that allows lines of more than 80 characters to be displayed as a series of 80-character lines.

LINK: The process of joining parts of a program into an integrated whole, generally performed by a piece of system software known as a linker.

LOAD: The process of placing a computer program into the proper memory locations to make possible its subsequent execution.

LOCAL AREA NETWORK (LAN): A collection of computers that are interconnected by some means of communication may be referred to as a network. A local area network is a network that is physically connected by some form of cable, usually restricted to relatively short distances.

LOGICAL UNIT NUMBER: A number used to identify a series of logical (as opposed to physical) peripheral devices. A single physical device may serve as several logical devices.

LOGO: A computer graphics system designed by Seymour Papert and coworkers at the Massachussets Institute of Technology. It is designed as an educational tool for children who might otherwise have difficulty understanding Cartesian coordinates.

LOW-PROFILE KEYBOARD: Refers to the thickness from top to bottom of the terminal keyboard. Thin keyboards are considered more ergonomically designed since they are more comfortable to work with on a desktop.

MACROASSEMBLER: A program made up of one or more sequences of assembly language statements, each sequence represented by a symbolic name.

MAINFRAME COMPUTER: A complex, expensive, large capacity computer system.

MARK SENSING: A device capable of reading pencil marks on documents up to a size of 13 inches x 8 inches. The marks can be positioned anywhere on the document.

MASS STORAGE DEVICE: Refers to various storage units with large capacity such as magnetic disk, drum, data cells, etc.

MB: See MEGABYTE.

MEGABYTE (MB): One million bytes (characters). Usually used in reference to disk storage or memory capacity.

MEMORY BOARD: A typical semiconductor memory board can be configured in 4K word increments. It provides addressing for the memory it contains, refresh and standby logic, and the bus interface.

MEMORY DRIVE: RAM configured to appear as a disk drive.

MENU-DRIVEN: Computer software that continually prompts the user with a list of options is referred to as menu-driven software.

MICROCOMPUTER: A computer which uses a microprocessor for its CPU.

MICROPROCESSOR: An integrated circuit that contains complete processing circuitry on a single silicon chip.

MIPS: Millions of instructions per second. A unit of measurement for CPU speed.

MODEM: From MOdulation and DEModulate; a device that allows a computer to communicate with other computers over telephone lines.

MONITOR: A video display used to enter commands and data into a microcomputer system and receive messages and output from the system.

MOS: See DYNAMIC METAL-OXIDE SEMICONDUCTOR CIRCUITS.

MOTHERBOARD: A printed circuit card with all of the bus signals prewired from connector-pin to connector-pin; the connectors are arranged on the motherboard in a way that would permit either card-edge fingers to be slipped into the connectors or an on-card connector to mate with one on the motherboard. Some systems integrate the motherboard with the frame that holds all of the cards in place.

MOTOROLA 68000 MICROPROCESSOR: A powerful 16-bit microprocessor which has 32-bit registers and comes closer to matching the power of mainframe processors than any of the microprocessors which preceded it.

MOUSE: An input device designed to ease terminal entry by allowing the user to move a cursor on the CRT by moving the mouse device across a flat surface. The idea is that the device allows the users to indicate a response by pointing to it.

MS-DOS: An operating system written by MICROSOFT which achieved the greatest attention when it was selected for the initial IBM Personal Computer.

MULTIMETER: A device used for measuring or testing characteristics of electrical circuits or parts. Multimeters typically test or measure AC or DC voltage, DC current, and ohms.

MULTIPROCESSING: Carrying out of two or more sequences of instructions at the same time in a computer.

MULTIPROGRAMMING: The interleaved execution of two or more programs by a computer, in which the central processing unit executes a few instructions from each program in succession.

MULTITASKING: Another term for multiprogramming.

MULTIUSER: The capability of a computer and operating system to have more than one terminal attached and in use at the same time.

NATIVE MICROPROCESSOR CODE: The instruction set that is peculiar to a particular microprocessor chip is called its native code.

NETWORK: A combination of paths for relaying messages from the originator to the recipient.

NODE: An individual work station or printserver, fileserver, or communications server on a local-area network.

NOISE: Hum, static pops, and other such annoyances during transmission of data.

NON-VOLATILE MEMORY: A memory type which holds data even if power has been disconnected.

NULL MODEM CABLE: A cable used to make possible the connection of two "slaves" or two "masters" as described by the RS-232C protocol.

NUMBER-CRUNCHING: Refers to computer applications which are CPU-bound, as opposed to I/O bound; statistical applications such as the calculation of variance and linear programming are examples of such applications.

NUMERIC KEYPAD: A keyboard oriented for numeric input to a computer. The layout of the keys is normally in standard calculator format.

OASIS: A microcomputer operating system.

OCR: See OPTICAL CHARACTER RECOGNITION.

OMR: See OPTICAL MARK READER.

OPERATING SYSTEM: A set of programs and routines which guides a computer in the performance of its tasks, assists the programs (and programmers) with certain supporting functions, and increases the usefulness of the computer's hardware.

OPTICAL CHARACTER READING WAND: An external device which picks up data by physically scanning it.

OPTICAL CHARACTER RECOGNITION (OCR): Refers to a process of using photosensitive devices to identify graphic characters, often of special type-font origin.

OPTICAL MARK READER (OMR): A computer data-entry machine that converts printed characters, bar or line codes, and pencil-shaded areas into a computer-input code format.

OPTIMIZED MACHINE CODE: Computer instructions that have been specially processed to improve efficiency in execution.

OVERLAY: A popular technique for bringing routines into high-speed memory from some other form of storage during processing, so that

several routines will occupy the same storage locations at different times. It is used when the total memory requirements for instructions exceed the available high-speed memory.

P-CODE: See PSEUDO-CODE.

P-SYSTEM: A microcomputer operating system.

PACKAGED SOFTWARE: Software designed to perform a specified function.

PACKED BINARY FORMAT: A more concise method for numeric data representation; data are stored at the bit level, ignoring character and word boundaries.

PARALLEL INTERFACE: Electronic circuitry that provides for the simultaneous transmission of several bits of data between two microcomputer components. A parallel interface requires a connector cable containing multiple wires.

PARITY CHECK: A means of detecting certain kind of errors in which an extra bit, carried along with each word, is set to zero or one so that the total number of zeroes or ones in each word is always made even or always made odd.

PASCAL: A high-level language developed by Niklaus Wirth.

PASSIVE FILTER: A filter for electricity consisting of passive elements such as resistors, inductors, or capacitors, but lacking active elements such as transformers.

PASSWORD PROTECTION: A feature of some operating systems that requires the user to identify a secret password in order to use the system or gain access to stored data.

PCN: See PERSONAL COMPUTER NETWORK.

PERSONAL COMPUTER: A personal desk-top computer provides stand-alone processing, storage, and I/O for one user in a compact, desk-top or smaller package.

PERSONAL COMPUTER NETWORK (PCN): One of several somewhat restricted computer networks developed for use with those microcomputers known as personal computers. See LOCAL AREA NETWORK.

PIC S9(9) COMPUTATIONAL: See COMPUTATIONAL FORMAT.

PIC X(80): A COBOL instruction allocating 80 bytes of memory storage for alphanumeric data.

PITCH: Refers to the number of characters per inch that can be printed on a line. 12-pitch means 12 characters per inch can be printed on a line.

PIXEL: Picture element. A pixel is a grid-cell representing the lowest level of visual detail of an image represented on the screen.

PLATEN: The hard roll of a typewriter or printer that serves as the backing against which paper is pressed as it is struck in the formation of a character.

PLATO: A system designed and implemented by Control Data Corporation to support computer-based education.

PORTABLE: When applied to software, capable of being run on multiple computers or under multiple operating systems.

POWER CONDITIONER: A device for improving the quality of power delivered from electrical outlets.

POWER SUPPLY: A source of electrical energy, such as a battery or power line, employed to furnish the tubes and semiconductor devices of an electronic circuit with the proper electric voltages and currents for their operation.

PRIMARY STORAGE: The internal memory of a computer; the immediate access store, as distinct from any secondary storage, such as that provided by disks.

PRINT SPOOLING: A feature that allows printed output to be stored and printed when the printer is available.

PROCESSING CYCLE: Microprocessors perform instructions as a series of simpler operations. Each of these simpler operations requires one cycle, a time set by the microprocessor's internal clock. A simple add operation may require 10 cycles on one microprocessor and only 3 on another.

PRODUCTION PROCESSING: Normal operational processing of a proven system; as opposed to testing.

PROGRAM GENERATOR: Generally a large detailed program which permits a computer to write other programs automatically.

PROTOCOL: Sometimes called handshake. The correct series of steps that allows a system to communicate with other computers.

PSEUDO-CODE (P-CODE): The intermediate code or object code generated by the UCSD Pascal compiler. In theory, p-code is the "machine language" for a pseudo-machine called the p-machine.

PSEUDO-COMPILER: A high-level language compiler that generates an intermediate code that requries the presence of a run-time system in memory when executed.

PUBLIC DOMAIN SOFTWARE: Software that is not copywrited and that may be freely copied.

QWERTY KEYBOARD: A standard typewriter keyboard. The top alpabetic line begins with the letters Q-W-E-R-T and Y.

RAM: See RANDOM ACCESS MEMORY.

RANDOM ACCESS: The capability to store information so that it can be retrieved independently of where it is stored in a file.

RANDOM ACCESS MEMORY (RAM): Data stored in RAM can be accessed on a direct basis, regardless of its location in storage. RAM is erasable so it is used to store application programs when they are running. When the program is finished, a different application can be run using the same memory.

RECORD DELIMITER: An ASCII character that is always interpreted as the beginning or the end of a new record.

RECORDING DENSITY: Refers to the number of bits in a single linear track measured per unit of length of the recording medium.

READ ONLY MEMORY (ROM): Nonerasable memory used to store instructions that are always needed by the computer such as built-in diagnostics.

RELATIVE ACCESS METHOD: A method by which records in a file may be located by determining their position relative to the first record in the file. Using a relative access method, records in a file may be accessed directly rather than sequentially.

RELOCATABLE PROGRAM: Refers to a program that is written so it may be located and executed from many areas in memory.

RESOURCES FOR THE AWARENESS OF POPULATION IMPACT ON DEVELOPMENT (RAPID): A project undertaken by the Futures Group to prepare a standard simple economic-demographic model on the Apple II+ computer.

RGB MONITOR: A color graphics CRT with separate guns for red, green, and blue. RGB monitors usually have higher resolution than composite CRT's such as television sets.

ROBUST: An operating system that is difficult to "crash" or bring to a halt is a "robust" operating system.

ROM: See READ ONLY MEMORY.

RS-232C INTERFACE: A technical specification published by the Electronic Association which specifies one way in which a computer communicates with peripherals (such as a modem or terminal).

S-100 BUS: The most popular standard bus system for microcomputers. It uses a hundred-line bus for connecting to external devices and transmitting or receiving data and control messages. The S-100 bus came into existence in 1976 when the two

main manufacturers of personal computers - MITS and IMSAI - supplied a common-line bus for connecting to external devices. The S-100 bus is now the IEEE-696 standard bus.

SAMPLE: A representative portion of a universe. A statistical sample is drawn in such a way that it more closely depicts the universe than does a completely random sample.

SCREEN ERASE: A command that may be sent to a CRT terminal to clear the CRT screen of all characters.

SCREEN HANDLING UTILITIES: A collection of programs or software routines for writing characters on a CRT terminal display.

SCROLL DOWN and SCROLL UP: A feature of terminals where images previously on the screen can be recalled.

SEALED SYSTEM: System in which the component parts are not accessible to the user.

SECONDARY STORAGE: Any means of storing and retrieving data external to the main computer itself but accessible to the program.

SEGMENT REGISTERS: Registers within a microprocessor CPU that provide a means for programmers to access segments of memory anywhere in a large memory without having to worry about their exact location. These segments are usually 64KB in size on microcomputers.

SEQUENTIAL ACCESS STORAGE: A form of digital computer storage in which the items of stored information become available only in a one-after-another sequence regardless of whether all or only part of the information is desired.

SERIAL INTERFACE: Electronic circuitry that provides for the transmission of data in a serial or bit-by-bit transmission manner between the CPU of a microcomputer and a peripheral device. A serial transmission requires only a single wire for communication. This makes possible the use of telephone equipment for serial communications.

SERIAL PORT: An external connection on a microcomputer which facilitates a serial interface, in which bits are passed one at a time to a single line.

SOFT VIDEO SWITCH: A switch controlled by software on the Videx video enhancer which allows the Apple II CRT to change between 40 column mode and 80 column mode.

SOFT-SECTORED FLOPPY DISK: Disks are formatted into tracks and sectors. When sectoring is a physical characteristic of a disk, it is said to be hard-sectored. When sectoring of a disk is done through software, that disk is said to be soft-sectored. The Apple II+, IBM PC, and 8" CP/M diskettes are soft-sectored.

SOFTWARE: The intangible set of instructions used to operate a computer. These instructions include the operating system, utilities, languages, translators, and application programs.

SOFTWARE PURCHASE AGREEMENT: A legal document by which a software vendor grants permission to the purchaser of a software package to use the software. Most software vendors require the purchaser to sign and return this document.

SOURCE CODE FORMAT: Code written using the commands of a high-level language is referred to as source code. Source code is the input for a compiler. The output from the compiler is called object code.

SOURCE LANGUAGE: The language in which a program is written, such as BASIC, COBOL, Pascal, or FORTRAN.

SPIKE: A short duration transient whose amplitude considerably exceeds the image amplitude of the associated signal.

SPLIT SCREEN DISPLAY: Some microcomputer software, particularly word processing and spreadsheet software, allows the display of two different sections of text on the screen at one time. Since the screen is being used for two simultaneous operations, the display is referred to as a split screen display.

SPOOLING: Refers to a procedure of temporarily storing data on disk or tape files until they can be further acted upon by a device such as a printer.

SPREADSHEET FORM: A form used for preparation of budgets which has a two-dimensional matrix format.

STACK: That portion of computer memory used to temporarily hold information.

STANDARD: A written guideline which enhances compatibility among language processors, floppy disk formats, internal buses, etc.

STATIC RAM: A type of random access memory which stores a bit of information within a flip-flop. It is asynchronous and does not require a clock. The contents of a static RAM remain stable forever, as long as power is available.

STATISTICAL TEST: A procedure whereby the truth of a hypothesis is investigated by examining a value of the test statistic computed from a sample and then deciding to reject or accept the hypothesis according to whether the value falls in the critical region or acceptance region.

STOP BITS: The last two bits transmitted in asynchronous data transmission to unequivocally indicate the end of a word.

STORAGE: Any device in a computer system used to retain information. Disks and magnetic tape cartridges are storage devices.

STORE: A British synonym for storage.

STRATUM: Divisions which group elements of a population. The strata can reflect regions of a country, densely populated or sparsely populated areas, or other groups.

STREAMING TAPE DRIVE: A tape drive lacking stop/start recording capability.

STRING HANDLING: The manipulation of strings which are collections of alphanumeric characters.

STRING VARIABLE: An array of characters that has a dynamically changing number of elements. The number of characters in a string variable at any moment is the length of the string. Both Apple II BASIC and UCSD Pascal, among other programming languages, allow for string variables.

STRUCTURED, MODULAR PROGRAMS: Program designed and implemented as modules which form a whole; format and use of meaningful names generally make them more readable and easier to modify.

SURGE: Sudden current or voltage changes in a circuit.

SURGE SUPPESSOR: A device that responds to the rate of change of a current or voltage to prevent its rise above a predetermined level.

SYSTEM CLOCK: A device used to supply time and optionally calendar information for the computer system.

SYSTEM DEGRADATION: Refers to the slowing of computer response time which a given user experiences when additional users or workloads are placed on the computer system.

SYSTEM INTEGRATION: The process of putting the parts of a microcomputer system together into a working system.

TEXT EDITOR: A text editor provides the system user with a convenient and flexible source text generation system. Source statements are entered via any source input device/file. The entered source text may then be output or statements may be added, deleted, or modified. The text editor permits the order of statements or groups of statements to be altered at any time.

TIMESHARING: Use of the same computer by one or more persons at the same time. Timesharing systems frequently consist of "dumb" terminals (no processing capability of their own) that communicate with a large, central computer.

TOGGLE SWITCH: An electrical switch with two settings, on and off.

TRANSACTION: An entry of data or a modification to existing data.

TRANSFORMATION: A process by which one or more variables are changed using such operations and functions as ordinary arithmetic, case delete, sine, cosine, log, and random numbers.

TRANSIENT: The instantaneous surge of voltage or current produced by a change from one steady-state condition to another.

TRANSMISSION RATE: The speed at which data are transmitted from one device to another. In working with a modem this rate is measured in baud or bits per second.

TRS-80: A popular 8-bit microcomputer produced by Tandy Radio Shack.

TURNAROUND: The elapsed time from submission of a program for processing to receipt of the output from the processing.

TUTORIAL: A training aid which is self-teaching.

TYPE-AHEAD BUFFER: A keyboard feature that allows the user to stack commands at the keyboard by entering requests while the system is still responding to previous requests.

UNBUNDLING: The concept of selling components such as hardware modules and/or software packages separately, as opposed to a "packaged system."

UNINTERRUPTABLE POWER SUPPLY (UPS): A device that provides a battery backup to supply electricity when the normal supply fails.

UNIVERSE DEFINITION: The criteria by which a value is determined to be included or excluded from a calculation.

UNIX: An operating system written by Bell Laboratories for DEC equipment; now being adapted to run on microcomputers, especially those employing the Motorola 68000 microprocessor.

UNIX-LIKE SHELL: The program that controls all interaction with the computer user in the operating system UNIX is called the shell. It provides many useful features for processing control.

USER-FRIENDLY: A term applied to software which attempts to assist the user by providing menus, screens which elicit information from the user, and information to assist the user.

UTILITY : A system software program that helps programmers and users perform specific types of common jobs. A program that sorts names and addresses is a common utility.

VARIABLE TYPING: Most programming languages allow for integer, real and character type variables. Pascal allows the user to define a new set of variable types through use of the TYPE declaration.

VARIANCE: The average of the squares of the deviations of all individual observations from their mean value.

VIDEO: Video refers to picture signals or to the sections of a television system that carry these signals. A video cassette is a device containing tape for video recording. A video disk is a disk for video recording. A video terminal is a device for displaying video recordings.

VIRTUAL CONSOLE: In a multiprocessing environment, a single physical console may serve as the console for several processes. In this case the console operates as several virtual consoles, each assigned to a different process.

VIRTUAL MEMORY: Virtual memory, ideally invisible to the user, involves the transfer of information one page or more at a time between primary and secondary memory, and adds only that time required for page swapping to the normal operating time.

VOLATILE STORAGE: Refers to a storge medium in which information cannot be retained without continuous power dissipation. Contrasted with nonvolatile storage.

WEIGHT: A factor which is applied to elements in a sample in order to inflate the sample to the level of the universe.

WINCHESTER DISK: A hard disk (as opposed to "floppy") which is completely enclosed, preventing contamination from the environment.

WORDPROCESSING: A term to describe the entry and editing of textual information using a computer.

WORKSTATION: The point from which a user communicates with a computer or with other users; incorporates the characteristics of a terminal with a degree of local intelligence and networking capability.

16-BIT MICROPROCESSOR CHIP: A microprocessor containing 16-bit registers and a 16-bit data bus.

32-BIT MICROPROCESSOR CHIP: A microprocessor containing 32-bit registers and a 32-bit data bus.

40-PIN: The silicon wafer or chip with its implemented circuitry can be bonded to a package which contains 40 pins that can be inserted in the holes on a board. The Intel 8085, Zilog Z80, and Z8002A CPU's are implemented in 40-pin packages.

80-PIN: The silicon wafer or chip with its implemented circuitry can be bonded to a package which contains 80 pins that can be inserted in the holes on a board. The Zilog Z8001A CPU is implemented in an 80-pin package.

8-BIT MICROPROCESSOR CHIP: A microprocessor containing 8-bit registers and an 8-bit data bus.

80-COLUMN TEXT CARD: A board designed for the Apple II+ to convert the image transmitted to the CRT from 40 columns of text to 80 columns of text per line.

# BIBLIOGRAPHY


| | Topic |
|---|---|
| Akers, Robert L. "Database Scorecard," Microcomputing, Vol. VI, No. 4 (4/82). | DBMS |
| "Alphanumeric Terminal Market Overview," Mini-Micro Systems, Vol. XV, No. 11 (11/82). | Terminals |
| Ambrosio, Johanna. "Ford Selects Victor 9000 for Execs," Information Systems News (December 27, 1982). | Victor |
| Anderson, Ronald. "The Proposed ANSI BASIC Standard," BYTE, Vol. 8, No. 2 (2/83). | BASIC |
| "Apple Takes on its Biggest Test Yet," Business Week, (January 31, 1983). | Apple |
| "Atari 400 and Atari 800 Home Computers," Datapro Directory of Small Computers, Datapro Research Corporation (October 1982). | Atari |
| Berst, Jesse. "The Latest Trends in Small Computers; What's Hot and What's Not," Interactive Computing (November/December 1981). | Trends |
| Blackhall, Malcolm. "The Multiuser OASIS Operating System: A Multiuser, Multitasking Operating System for the Z80," Microprocessor Operating Systems, Vol. II. | OASIS |
| Blundell, Gregory S. "Personal Computers in the Eighties," BYTE , Vol. 8, No. 1 (1/3). | Trends |
| Brody, Herb. "Machines That Read Move Up a Grade," High Technology, Vol. 3, No. 2 (2/82). | OMR |
| Bunnell, David, and Currie, Eddie. The Age of Altair," Personal Computing, Vol. 1, No. 1 (March 1982). | History |
| Bunnell, David. "A PC Exclusive Interview with Software Guru Bill Gates," PC, Vol. 1, No. 1. | Composite |
| Butier, John. "Hard Facts on Hardware Service," Desktop Computing (March 1983). | Maintenance |
| Calhoun, Craig J. "The Microcomputer Revolution," Sociological Methods and Research, Vol 9, No. 4 (May 1981). | Composite |
| Carlson, William E., and Fisher, David A. "First Complete Ada Compiler Runs on a Micro," Mini-Micro Systems, Vol. XV, No. 9 (9/82). | Ada |

Catacosinos, William J., and Witherow, John. "Selecting A Low-End Display Terminal", Mini-Micro Systems, Vol. XV, No. 11 (11/82). Terminals

Collins, T.W. "Social Science Research and the Microcomputer," Sociological Methods and Research, Vol. 9, No. 4 (May 1981). Composite

Doyle, Thomas. "Pascal Standards," BYTE, Vol 7, No. 2. Pascal

Edlin, Jim, and Bunnell, David. "Taking the Measure," PC, Vol. 1, No. 1 (February 1982). IBM

Fawcette, James. "Ada Tackles Software Bottleneck," High Technology, Vol. 3, No. 2, (2/83). Ada

Ferrarini, Elizabeth M. "Invasion of the Micro-computers," Computerworld (June 1, 1981). Composite

Flippin, Allan. "The 16-bit Time Trials," Microcomputing, (October 1980). Microprocessors

"Flourishing Micros Offer Real Advantage," Computerworld (August 30, 1982). Advantages

Frank, Werner L. "Micro Software Hardware: The Profit Picture," Computerworld (September 18, 1982). Marketing

Fried, Louis. "Nine Principles for Ergonomic Software", Datamation, Vol. 28, No. 12 (11/82). Software

Garetz, Mark. "Tips on Buying a Micro-Based Business System," Computerworld (November 15, 1982). Sys Selection

Good, Phillip I. "Software Makes the System," Computer Decisions (February 1981). Sys Selection

Gordon, Jason H. "Choosing the Best Tape Drive," Mini-Micro Systems, Vol. XV, No. 10 (10/82). Tape Drives

Greenberg, Robert B. "The UNIX Operating System and the XENIX Standard Operating Environment," BYTE, Vol. 6, No. 6 (6/81). UNIX

Hoard, Bruce. "Local-Area Network Standards: The Long Wait," Computerworld, Vol XVI, No. 52 (12/27/82). Networks

Horwitt, Elizabeth. "Let Your Computer Really Reach Out," Business Computer Systems, September 1982. Modems

| | |
|---|---|
| Horwitt, Elizabeth. "The Wonders of Word Processing", Business Computer Systems, 11/82. | Word Processing |
| Horwitt, Elizabeth. "When More May Not Be Better," Business Computer Systems, Vol. 2, No. 2 (February 1983). | Sys Selection |
| Hughes, Phil. "The Operating System of the Future," Microcomputing, Vol. VI, No. 6 (6/82). | Op Systems |
| James, E.B. "Microelectronics: The Impact on Computer Centres," Computer Journal, Vol. 24 (February 1981). | Composite |
| James, E.B. "Personal Computing Systems for Research and Development," (Imperial College, January 1981). | Composite |
| James, E.B. "The User Interface: How We May Compute," from Computing Skills and the User Interface, M.J. Coombs and J.L. Alty, eds., (Academic Press:London, 1981). | Software |
| James, E.B. "Thoughts on Networking" (Imperial College, 1982). | Networks |
| Johnson, Bob. "Don't Let Users Buy Their Own Micros," Computerworld (November 22, 1982). | Sys Selection |
| Johnson, Bruce W. "OCR Advances Widening Applications Horizon," Computerworld, Vol. XVI, No. 48. | OCR |
| Jones, Edward. "Shopping Around," Desktop Computing (October 1982). | Marketing |
| Kaufman, Felix. "Distributed Processing," Data Base, Vol. 10 (Summer 1978). | Dist processing |
| "Kaypro II and Kaypro 5," Datapro Directory of Small Computers, Datapro Research Corporation (December 1982). | Kaypro |
| Kenealy, Patrick. "Database Software Packages for Micros," Mini-Micro Systems, Vol. XV, No. 9 (9/82). | DBMS |
| Kenealy, Patrick. "WP Software Advances Rapidly," Mini-Micro Systems, Vol. XVI, No. 5, (5/82). | Word Processing |
| Kenealy, Patrick. "Personal Computers: a New Generation Emerges," Mini-Micro Systems, Vol. XV, No. 8 (August 1982). | Composite |

Kernighan, Brian W., and Ritchie, Dennis M. The C Programming Language, (Prentice-Hall, Inc.: Englewood Cliffs, NJ, 1978). — C

Kline, David. "The Micro Comes to Pakistan," Datamation (August 1982). — Mic in Pakistan

Kocker, Christopher, and Keith, Michael. "Six Personal Computers from Japan," BYTE, Vol. 7, No. 5 (5/82). — Japanese PCs

Kotelly, George. "Personal Computer Networks," EDN, Vol. 28, No. 5 (3/3/83). — Networks

Kotelly, George. "EDN's Third Annual Microcomputer Operating Systems Directory," EDN, Vol. 27, No. 18 (9/15/82). — Op Systems

Kurtz, Thomas E. "On the Way to Standard BASIC", BYTE, Vol. 7, No. 6 (6/82). — BASIC

Lehman, John A. "PL/I for Microcomputers," BYTE, Vol. 7, No. 5 (5/82). — PL/I

Leibson, Steve. "The Input/Output Primer, Part 2: Interrupts and Direct Memory Access", BYTE, Volume 7, No. 3 (3/82). — DMA

Leibson, Steve. "The Input/Output Primer: Part 3: The Parallel and HPIB (IEEE-488) Interfaces," BYTE, Vol. 7, No. 4 (4/82). — Interfaces

Leibson, Steve. "The Input/Output Primer: Part 4: The BCD and Serial Interfaces", BYTE, Vol. 7, No. 5 (5/82). — Interfaces

Lemmons, Phil. "Victor Victorious: The Victor 9000 Computer," BYTE, Vol. 7, No. 11 (November 1982). — Victor

Lines, Vardell. Minicomputer Systems, (Winthrop Publishers, Inc.: Cambridge, 1980). — Composite

Love, Nancy. "Microcomputer Standards Process Runs Gamut from Frustration to Fruition", Mini-Micro Systems, Vol. XV, No. 7 (7/82). — Standards

Lu, Cary. "Microcomputers: The Second Wave," High Technology (September/October 1982). — Composite

Magel, Kenneth. "A Report on a Pascal Questionnaire," ACM Sigplan Notices, Vol. 17, No. 10 (10/82). — Pascal

| | |
|---|---|
| Makmann, Tom. "Winchester Backup For Less Than 'Six Bits' (75 cents) Per Megabyte," Mini-Micro Systems, Vol. XV, No. 8 (8/82). | Disk Backup |
| Marcellus, Daniel H. "A Fearless Look at Micro Changes," Microcomputing, Vol. VII, No. 3 (3/3). | Trends |
| Markoff, John, and Dvorak, John C. "Osborne Unveils its Second Generation," Infoworld, Vol. 5, No. 18 (May 2, 1983). | Osborne |
| Marks, Gregory A. "Microcomputers: Basic Choice Factors" (The University of Michigan, June 1982). | Composite |
| Matthews, John B., MD. "Converting Apple DOS and Pascal Text Files," BYTE, Vol. 7, No. 4 (April 1982). | Apple |
| Metcalfe, Bob. "Controller Transceiver Board Drives Ethernet into PC Domain," Mini-Micro Systems, Vol. 16, No. 1 (January 1983). | Networks |
| "Microcomputers and Agriculture Management in Developing Countries: Workshop Proceedings" (USDA, June 1982). | Composite |
| "Microprocessor Applications - International Experience," Mini-Micro Software, Vol. 5, No. 2. | Applications |
| Moore, Robin. "Apple's Enhanced Computer, the Apple IIe," Vol. 8, No. 1 (February 1983). | Apple |
| Mullin, Grover. "Mixing Disk Drive Ingredients for Your Applications", Mini-Micro Systems, Vol. XV, No. 11 (11/82). | Hard disks |
| Naiman, Arthur. "Word Processing: How Packages Stack Up," Business Computer Systems, 4/83. | Word Processing |
| Norman, Donald A. "The Trouble with UNIX," Datamation, Vol. 27, No. 12 (11/81). | UNIX |
| Ogdin, Carol Anne. Microcomputer Management and Programming (Prentice Hall, Inc.: Englewood Cliffs, NJ, 1980). | Composite |
| "Osborne I," Datapro Directory of Small Computers, Datapro Research Corporation (July 1981). | Osborne |
| Overgaard, Mark. "Implementing the UCSD P-Systems," Mini-Micro Systems, Vol. 15, No. 9 (September 1982). | P-System |

| | |
|---|---|
| Papert, Seymour. Mindstorms, (Basic Books: New York, 1980). | Programming |
| Porter, James N. "Floppy-disk Drives: A Truly Flexible Industry Standard", Mini-Micro Systems, Vol. XV, No. 2, 2/82. | Floppy Disks |
| Porter, James N. "Rigid Disks: The New Small System Alternative", Mini-Micro Systems, Vol. XV, No. 2 (2/82). | Hard disks |
| Pournelle, Jerry. "A Slew of Languages, a Slap at Documentation and a Curse at Keyboards," BYTE, Vol. 7, No. 12 (12/82). | Languages |
| Pournelle, Jerry. "Semidisk, Software Tools, the BDOS Blues, Power and LISPs," BYTE, Vol. 7, No. 8 (8/82). | Languages |
| Pournelle, Jerry. "User's Column: Sage in Bloom, Zeke II, CBIOS Traps, Language Debate Continues," BYTE, Vol. 8, No. 3, (March 1983). | Sage |
| "Questions Before Buying," Computerworld (January 25, 1982), Special Report. | Sys Selection |
| Rosch, Winn l. "Hard Disks Made Easy," PC, Vol. 1, No. 10 (February 1983). | Hard Disks |
| "Sage II," Datapro Directory of Small Computers, Datapro Research Corporation (November 1982). | Sage |
| Schindler, Jr., Paul E. "Multiple Sub-5.25-Inch Floppy Designs Foreseen", Information System News, 1/10/83. | Floppy Disks |
| Segal, Hillel. "Altos Sows Performance Gap Between Disks," Computerworld (January 11, 1983). | Altos |
| Segal, Hillel. "Chieftain 9822 Gives High Performance Rates," Computerworld, Vol. 16, No. 10 (March 8, 1982). | Chieftain |
| "Servicing Your Systems," Datapro Small Computer News (July 1981). | Maintenance |
| Simpson, David. "Small-Business Systems Solve Big Problems," Mini-Micro Systems, Vol. XV, No. 6 (6/82). | Systems |
| Slater, Leland W. "Everything You Ever Wanted to Know About Microcomputers," Computopics (1982). | Composite |

| | |
|---|---|
| Smith, Amy E. "Power Line Perils," Business Computer Systems (September 1982). | Power |
| St. John, Robert. "Proposed Policy Memo Is First Step to Control," Small Systems World (September 1982). | Policy |
| Stein, Donna. "The Calc Wars," Business Computer Systems, 9/82. | Spreadsheet |
| Stein, Donna. "Your Business Image," Business Computer Systems, 11/82. | Graphics |
| Stephens, Andrew J. "Microcomputers in Developing Countries," (MSU Conference, 1982). | Networks |
| Stockman, Robert. "Microcomputers Stretch the Limits of Planning," Government Data Systems (November/December 1982). | Applications |
| Stone, Jeffrey. "Microcomputer Selection Study," (World Bank, July 16, 1981). | Composite |
| Taylor, Roger, and Lemmons, Phil. "Upward Migration: Part 2: A Comparison of CP/M-86 and MS-DOS", BYTE, Vol. 7, No. 7 (7/82). | Op Systems |
| "The Microprocessor Grows Up," EDP Auditor (Winter 1980). | Composite |
| Thomas, Rebecca Anne, and Yates, Jean. "UNIX," Computerworld, Vol. XVI, No. 2 (1/11/82). | UNIX |
| Torode, John. "Getting Down to Business with Local Area Networks," Microcomputing (June 1982). | Networks |
| Tsantes, John. "Power Sources," EDN, Vol. 27, No. 24 (12/17/82). | Power |
| Umeh, Fidelis M. "Small Systems World Editorial Board Holds Roundtable Discussion on Key Topics," Small Systems World (July 1982). | Composite |
| "Wang Professional Computer," Datapro Directory of Small Computers, Datapro Research Corporation (February 1983). | Wang |
| Watt, Molly. "What Is LOGO?" Creative Computing (October 1982). | LOGO |

Wharton, John, and Kildall, Gary. "The CP/M Operating System: A Universal Control Program for Eight-bit Microcomputer Systems" from Microprocessor Operating Systems, Volume II, John Zarella, ed., (Microcomputer Applications: Suisun City, California, 1982). CP/M

Williams, Greg. "The Lisa Computer System," BYTE, Vol. 8, No. 2 (February 1983). Lisa

Williams, Gregg. "A Closer Look at the IBM Personal Computer", BYTE, Vol. 7, No. 1 (1/82). IBM

Williams, Gregg. "Three Versions of APL," BYTE, Vol. 6, No. 4 (4/81). APL

Wingfield, Mike. "Build an Intercomputer Data Link," BYTE (April 1981). Communications

Woteki, Thomas H., and Sand, Paul A. "Four Implementations of Pascal," BYTE, Volume 7, No. 3, (3/82). Pascal

Zaks, Rodnay. From Chips to Systems (Berkeley: Sybex,1981). Composite

Zientara, Marguerita. "User-Maintenance Alternatives Abound," Computerworld (February 1983). Maintenance

"8-bit vs. 16-bit: A Decision for Business," Business Computer Systems (September 1982). Sys Selection

*U.S. GOVERNMENT PRINTING OFFICE: 1983-0-421-997/5231